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Forthcoming Events.

JUNE 19 to 23.

International Foundry Trades Exhibition.—At Bingley Hall, Birmingham.

JUNE 25 to 27.

Foundry Technical Congress.—Bingley Hall, Birmingham.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1923-24, Oliver Stubbs, M.I.Mech.E., Openshaw, Manchester.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, 38, Victoria Street, London, S.W.1.

Lancashire: T. Makemson, 21, Beresford Road, Gorse Hill, Stretford, Manchester.

Birmingham: H. James Roe, 33, Herbert Road, Bearwood, Birmingham.

Sheffield: R. Village, Albion Foundry, Whittington Moor, near Chesterfield.

Scottish: J. Bell, 60, St. Enoch Square, Glasgow.

London: H. G. Sommerfield, Charterhouse Chambers, Charterhouse Square, London, E.C.1.

Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.

East Midlands: H. Bunting, 17, Marcus Street, Derby.

Coventry: J. M. Meston, 37, Melville Road.

West Riding of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.

Wales and Monmouth Branch: J. J. McClelland, M.I.Mech.E., Druslyn, Bishops Road, Whitechurch, Glam.

Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

The Newcastle Convention.

From every point of view the Institute of British Foundrymen Convention, which was held last week in Newcastle, was the most successful on record. From the technical aspect, the Papers presented were of an exceptionally interesting character, and there was exhibited that keen desire for discussion which is now characteristic of the Institute. The thesis presented by Mons. Chevenard on "The Dilatometric Analysis of Alloys" is one around which will centre much thought, and probably this method of research will be taken up—as it should be—by some of our well-known specialists in the metallurgy of cast iron.

Mr. C. W. H. Holmes' Paper on Oil-Sand Cores was perhaps the clearest exposition of the basic principles underlying this intensely practical subject ever given.

The American Exchange Paper, by Messrs. R. J. Anderson and M. E. Boyd, on "The Production of Castings in Permanent Moulds," is a most comprehensive review of the whole field, and places in the hands of British metallurgists a finished account of the progress so far made.

The other Papers, by Messrs. Van Aarst, Northcott and Logan, were of a very high standard.

The works visits provided were on almost too generous a scale, for no less than fifteen establishments threw open their doors to the visitors, and time only permitted the visiting of two. On behalf of the foundry trades of the country, we offer our sincere thanks to the directors, managers, and the gentlemen who acted as guides, for the courtesies extended.

Socially, this Convention was easily the best ever organised. No less than ten functions were arranged and carried through without a single hitch of any character. The congratulations showered upon the local reception committee were in no respect too generous, and the thanks of the foundry industry are due to these gentlemen, for a successful conference does a lasting service to the Institute, and therefore to the great industry it represents—Capt. Wood, Messrs. Young, Parsons, Victor Stobie (who was responsible for the catering arrangements), and especially Mr. Colin Gresty, who acted as secretary.

To the newly-elected President, Mr. R. O. Patterson, we offer our congratulations. Mr. Patterson is a well-known and highly-respected Tyneside foundry owner who has had a wide business experience, coupled with a first-hand knowledge of foreign foundry conditions. Mr. Oliver Stubbs, the retiring President, has set a very high standard to any President to uphold, but no better successor than Mr. Patterson could be found, and undoubtedly, under his guidance, the Institute will continue to make good progress.

The election of Mr. John Cameron to the vice-presidential chair was extremely popular. Mr. Cameron is a well-known Scotch foundry owner, who also has interests in India. It may now be possible that a branch of the Institute may be formed in this Empire.

As is now usual, there was a fair sprinkling of foreigners present, and the American Foundrymen's Association was represented by Mr. Miles, a past-president, and the Association Technique de France by Prof. Chevenard, one of the world's best-known scientific metallurgists.

Finally, the annual convention of the Institute has now reached a very high standard, which, at all costs, must be maintained.

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THE INSTITUTE OF BRITISH FOUNDRYMEN.

Newcastle Annual Convention.

The twenty-first Annual Convention of the Institute of British Foundrymen was held in Newcastle-on-Tyne from Wednesday, June 4, till Friday, June 6.

The business of the Convention opened on Wednesday, June 4, in the Lecture Theatre of the Literary and Philosophical Society, Westgate Road. Mr. Oliver Stubbs, the retiring President, presided, and there were a large number of members and visitors present.

Civic Reception.

The members and visitors were welcomed by Dr. R. W. Simpson (the Deputy Lord Mayor of Newcastle-on-Tyne), the Right Hon. Lord Joicey, J.P. (President of the Newcastle and Gateshead Incorporated Chamber of Commerce), and Sir Theodore Morison (Principal of Armstrong College and Vice-Chancellor of the University of Durham).

Dr. Simpson apologised for the absence of the Lord Mayor, who was absent in London on a very important engagement. The industry with which the Lord Mayor was associated (the building industry) was passing through a very difficult time, and on that day there was a very critical meeting in London — critical not only from the industrial, but the national, point of view — and he had considered it his duty to attend. Dr. Simpson hoped the Members of the Institute would accept that explanation, and the Lord Mayor's regret at the same time.

Mr. R. O. Patterson (President).

Mr. R. O. Patterson, who is now President of the Institute of British Foundrymen, was born in 1876. He was educated in Newcastle-on-Tyne and on the Continent. Mr. Patterson has travelled extensively. His first long trip was to the United States in 1898. His next tour was to Australia, and his third excursion was as a soldier to take part in the Boer War. He again visited the States in 1919 to take part in the American Foundrymen's Association Congress. In 1920 Mr. Patterson was elected president of the Newcastle Branch, and the following year junior vice-president of the parent body. He is well known in northern business circles, being a director and works manager of Messrs. Smith, Patterson Company, Limited, of Blaydon-on-Tyne, who are manufacturers of grey-iron and non-ferrous castings, and are general sanitary engineers.

Dr. Simpson, continuing, said he was very glad that it had fallen to his lot to welcome such an important Institute. He understood that this was its twenty-first year, and he took it as a very happy incident that he happened to be the Deputy Lord Mayor, and had the task of welcoming the Institute on the occasion of its majority. He hoped it would have a very successful future. He understood that it existed for the linking up of science and industry, and he could imagine no happier object for any body than to carry out that very high ideal. At the present time, in this country, we are suffering a good deal from want of sympathy and want of co-operation between the scientific worker and the manual worker, and he could see that if the ideal of the Institute was carried out enthusiastically we should begin to get to the end of a good deal of our industrial unrest, which, at the present moment, is such an affliction.

The Industries of the Newcastle District.

Speaking of the industries of Newcastle, he pointed out that the factories and works which would be visited by the members in the course of their stay in Newcastle were the pride of the North of England. The Newcastle people were very delighted to think that the turbine, a great engineering proposition, was invented and perfected on the Tyne, as was also the locomotive; so that two of the most outstanding engineering triumphs in the whole world were originated in the Tyne Valley. On behalf of the Lord Mayor, the Corporation and the citizens of Newcastle, he wished the members a very profitable and enjoyable sojourn in Newcastle, and hoped that the meeting would benefit both the Institute itself and the nation, through the efforts of the Institute.

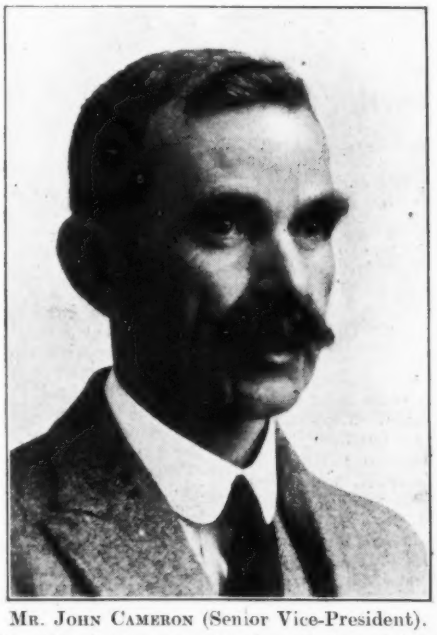
Tyneside's Notable Engineers.

The Rt. Hon. Lord Joicey said that as the representative of the Chamber of Commerce, he was very glad indeed to have the honour of receiving so distinguished a body as was represented by the Institute, which was doing splendid work. Although the Institute had only been in existence twenty-one years it had already made its mark in the industries it represented. He had been told that the educational portion of the Institute's work was having a very good effect upon the various industries and upon the young men who were likely to carry them on in the years to come. Depend upon it, he said, in these days it was absolutely necessary, if we were to hold our own, to take advantage of every means in our power to develop our industries in order to compete with those in every other part of the world.

He realised that in the future this country would have to face such competition as it had never had to face before. Many of those whom we had been accustomed to supply with our various manufactured goods were beginning to manufacture them for themselves, and many of them were even supplanting the industries of this country. When it was considered what that competition would mean, he was sure the members of the Institute would realise the importance of bringing all those who represented the industry to the very highest point of efficiency that could be attained. As had been said by the Deputy Lord Mayor, Newcastle was practically the birthplace of the locomotive, and, indeed, of the development of railways, because those great men, George and Robert Stephenson, who had had so much to do with the locomotive, were the men who took charge of the development of the railways, and to whom the country owed so much. Then there was Lord Armstrong, who, of course, had built our great ships, and was such an inventor with regard to ordnance. Following him, there was Sir Charles Parsons, the inventor of the turbine, to whom the country owes so much. Long may he remain with us to carry on his splendid work. There were many more such names that he could mention which would show, at all events, that the North of England has contributed as much as any other part of the country to the great developments of industry of which we were so proud. The Chamber of Commerce represented all the various industries. It was not limited to the City of Newcastle, but extended over the whole of the district—Tyne-

side, the Wear, Northumberland and Durham—and these industries had found it to their advantage to become connected with the Chamber of Commerce. The Chamber of Commerce, which he represented, was one of the oldest and, he believed, was proved to be one of the most influential in the country, and in these days, with Governments who are so keen and so apt to interfere with our various industries, it was necessary that our industries should have these organisations in order to see that the legislation which Governments were passing was not likely to be such as to injure these industries. Finally, on behalf of the Chamber of Commerce, he extended to the Institute the heartiest welcome to Newcastle, and hoped that their visits to various works would be useful to the members.

SIR THEODORE MORISON also offered a very hearty welcome in the name of the University of Durham, and, in especial, of Armstrong College. He hoped that the members of the Institute would find time to look at the laboratories at Armstrong College, and assured them of a most hearty welcome to the Scientific Departments of the College. It was a matter of regret that their visit happened to coincide with one of the rather gloomy portions of the academic year, *i.e.*, they were now holding the annual examinations, and he feared that neither examiners nor examinees would be able to give the members the whole-hearted attention which they would have been glad to give if they had come in more fortunate times. The University and the Institute had a great deal in common, because both were working upon the same problem, or rather on different ends of the same problem. The University was engaged in the elaboration and investigation of general principles of science, whilst the Institute was engaged upon the practical application of these principles, and he had felt very strongly that neither side could achieve very much without the other. It was necessary that there should be a body of independent investigators who were pursuing true science for its own sake without regard to its practical or commercial application, but, at the same time, he assured the members of the Institute, as a member of the University, that it was of considerable benefit to those who were following pure science to have continually brought before them those practical problems and difficulties with which the members of the Institute were in daily contact. The two things could not work efficiently unless brought into wholesome co-operation, and it was on these grounds that he felt he had some claim to extend to the Institute a very hearty welcome on behalf of the University.



MR. JOHN CAMERON (Senior Vice-President).

Mr. John Cameron is managing director of Messrs. Cameron & Robertson, Limited, of Kirkintilloch, near Glasgow, and also a director of the Eastern Light Casting Company, Limited, of Bengal, India. He is the elder son of the late Mr. John Cameron, and became the sole proprietor of this firm in 1890, and remained so until the concern became a private limited company in 1899. Mr. Cameron joined the Institute of British Foundrymen in 1917, and the following year represented the Scottish Branch on the General Council. That his services were appreciated was shown by the fact that he was elected a member of the council in 1921. He is also a member of the Council of the British Cast Iron Research Association. Mr. Cameron has made a study of semi-steel, and has read Papers on this subject at Glasgow, Falkirk, Sheffield, and before the 1922 Birmingham Convention.

Presentation of the "Oliver Stubbs" Gold Medal.

THE PRESIDENT then asked the Deputy Lord Mayor to present the "Oliver Stubbs" Gold Medal to Mr. John Shaw, of Sheffield. It would be agreed that the decision to present the Medal to Mr. Shaw was a good one. Everybody appreciated very much the work that Mr. Shaw had done for so many years, and more particularly during the last 18 months, in connection with test bars. As Sir Theodore Morison had said, there was a great necessity for co-operation between the practical and the scientific side, because one without the other was of no use. The Institute were doing their best to carry this work along, and they thought they could claim that, as a result of their work, they had been of immense benefit to the industry, and particularly to the employers, because they had been able to supply the employers with very well trained men to manage the foundry side of the engineering industry—better trained than ever before.

THE DEPUTY LORD MAYOR, in presenting the Medal, referred to it as the equivalent of the "Nobel Prize." It was given to the man who, during the session, had done, in the opinion of the Executive, the most outstanding work for the good of the Institute, the members, and the industry. That encouraged and recompensed research, which was very badly recognised in this country, and looked upon with the greatest suspicion by the Government and by the "Powers that Be" generally, and the presentation of the Medal was one more proof of the up-to-dateness and the good sense of the Institute. He congratulated Mr. Shaw upon winning the Medal.

The Medal was then presented to Mr. Shaw, amid loud applause from the members.

MR. SHAW, in acknowledgment, said he appreciated the presentation of the Medal, not merely for its intrinsic value, but for the good feeling and esteem of the members, which it betokened. What little he had been able to do he had done purely and simply for the trade—a trade which was not understood, he was afraid, by University people, but one which would come into its own, for Diesel engine work could not go unless the metal used was improved.

Presentation of Illuminated Address to Mr. Reason.

THE DEPUTY LORD MAYOR then presented to Mr. H. L. Reason (President of the Institute, 1922-23) an Illuminated Address, which it is the custom to present to retiring Presidents. In doing so, he said that one of the most valuable things in this world was regard for one's fellowmen, and the good opinion of the men one had been working with, and one of the most delightful things a man could treasure was a tangible expression of that good will. He congratulated Mr. Reason upon having been President of such a distinguished body, and upon having this very tangible emblem of the good will of the members.

The Address was presented amid applause.

MR. H. L. REASON, expressing his appreciation, said he had been connected with the Institute for many years. Whatever he had done had always been a work of pleasure, and he numbered some of his best friends among the members of the Institute. A presentation of this sort served to remind one, particularly in the evening of one's years, that one had done something in one's humble way for the benefit of the industry, to which they were all so proud to belong.

THE PRESIDENT, in proposing a vote of thanks to the Deputy Lord Mayor, Lord Joicey and Sir Theodore Morison for having given the members of the Institute such a splendid welcome, said they all appreciated it very much indeed, and were very pleased to think that the poor sand rat was beginning to be acknowledged as a very necessary "evil"—as some people might say—in the engineering industry.

XUM

The vote of thanks was accorded with acclamation.

THE DEPUTY LORD MAYOR, replying on behalf of himself, Lord Joicey and Sir Theodore Morison, said the measure of their thanks would be judged by the amount of the enjoyment of the members whilst in Newcastle. If the members of the Institute enjoyed themselves as well as it was hoped they would, the people of Newcastle would all be very pleased indeed.

THE ANNUAL GENERAL MEETING.

The 21st annual general meeting was then held.

The minutes of the last annual general meeting having been read, confirmed and signed,

THE PRESIDENT proposed that the annual report of the General Council for the Session 1923-24 be adopted.

Annual Report and Balance Sheet.

The General Council have pleasure in presenting to the Members their Report of the progress and work of the Institute during the past Session 1923-24.

Four General Council Meetings have been held during the Session at Manchester, York, Manchester and London respectively. Representatives of the Branches from all parts of the country have attended the Meetings, and there has been an average attendance of thirty.

The respective Branches have the following members attached :—

	Members.	Associate Members.	Associates.	Total.
Birmingham	56 (54)	85 (88)	14 (17)	155 (159)
Coventry	29 (32)	41 (50)	4 (8)	74 (90)
East Midlands ..	32 (31)	46 (66)	7 (9)	85 (106)
Lancashire	99 (96)	174 (161)	6 (4)	279 (261)
London	80 (88)	64 (70)	11 (9)	155 (167)
Newcastle	84 (87)	100 (105)	67 (66)	251 (258)
Scottish	65 (70)	150 (153)	21 (17)	236 (240)
Sheffield	86 (93)	89 (100)	12 (13)	187 (206)
West Riding of Yorks.	36 (34)	46 (44)		82 (78)
Wales and Mon.	16	11		27
General	21 (31)	4 (13)		25 (44)
	604 (616)	810 (950)	142 (143)	1556(1609)

The figures in brackets are for the session 1922-1923.

The total number of Members on the Roll of the Institute on April 30, 1924, was 1556. The Council regret to have to report that 12 deaths have taken place during the year, one of these being late Past-President, Mr. Chas. Jones, of Cardiff, who filled the position of President in 1912, and took considerable interest in the work of the Institute.

ANNUAL CONFERENCE 1924.—This will be held on June 4, 5 and 6, on the premises of the Literary and Philosophical Society, Newcastle, by the kind permission of the authorities.

"OLIVER STUBBS" GOLD MEDAL.—The second medal was awarded to Mr. W. H. Sherburn, of the Lancashire Branch, the award being made on the ground of his paper entitled "Evolution of the British Foundryman," and for meritorious services rendered to the Institute from its inception as well as for the example and precepts given to the Members of the Institute and industry in general.

GENERAL COUNCIL.—The Members who retire in accordance with the Rules are Messrs. A. R. Bartlett, H. Pemberton, J. Shaw and H. Sherburn. Messrs. Bartlett, Pemberton and Shaw offer themselves for re-election. As six were elected at the last Conference only four will require to be elected at the Newcastle Conference to complete the ten Members as provided for in the Bye-Laws.

STANDARDISATION OF TEST BARS.—The Tentative Specification has been issued and submitted for the consideration of the various Technical Societies. No definite steps have been taken to place the matter before the B.E.S.A. because it is desirous that agreement shall be arrived at with the Special Committee set up by the B.C.I.R.A. Owing to certain circumstances this Committee has not completed its work, but there is a promise that a joint meeting will be held, probably before this report is published. A number of large firms have tried the various size bars in practice and are unanimous that, if test bars are specified, the new specification will give more information than any one sized bar.

INTERNATIONAL TESTS.—A strong Committee has been set up to consider this matter. A member has been appointed from each of the Countries represented at the Paris Convention in September last. Mons. Portevan was elected Chairman, and Mons. Ronceray, Honorary Secretary. So far Mr. Shaw has not called the I.B.F. Committee together to consider this question, as it will be better to settle the question of the British Specification first. That will, of course, guide the Committee in their deliberations on the International Bar.

DIPLOMAS.—Since the last Conference a new Diploma Award has been prepared, and these have been awarded to the following for papers read at Meetings:—J. E. Bates, Coventry; C. Bickerton, Burnley; T. Brown, Sheffield; W. T. Evans, Derby; G. H. Judd, Coventry; J. Masters, Burnley; D. McQueen, Glasgow; J. D. Nicholson, Newcastle; W. Rawlinson, Lancashire; F. R. Rowe, Manchester; O. Smalley, Newcastle; O. Smalley, for paper read at Sheffield; John Watson, formerly of Sheffield; and C. Webster, Sheffield.

CERTIFICATES.—During the past Session a form of Certificate of Membership has been prepared and adopted. It was decided by the General Council that a Certificate should be given to all Members and Associate Members of the Institute whose subscriptions were paid up for the year 1923.

BRITISH CAST IRON RESEARCH ASSOCIATION.—In the last Conference Programme it was announced that Dr. Percy Longmuir had been appointed Director of Research, but he was compelled to resign at the end of his first year on account of ill-health. Mr. Thos. Vickers, who had acted as Secretary of the Association from its conception, has also resigned, and the Council has appointed Mr. J. G. Pearce to fill the offices of Director and Secretary. The Association has the benefit of the services of Mr. J. E. Fletcher as Consultant.

The acute depression in the Foundry trade has prevented the Association hitherto from entering on an ambitious research programme. There are now very distinct signs of improvement, and an active research programme is proceeding.

AMERICAN FOUNDRYMEN'S ASSOCIATION. — The Members generally are aware that in August last year we received a delegation from the American Foundrymen's Association, and that they were entertained in London, Sheffield, Manchester, Birmingham and Coventry. They afterwards attended the French International Conference in Paris along with a large number of our own Members. We have every reason to believe that the Members of the A.F.A. returned to the States feeling that the goodwill and hospitality shown to them had done much to cement the relationship between the two countries in the foundry trade.

WALES AND MONMOUTH BRANCH.—This new Branch has recently commenced operations with efficient Officers and we have every reason to hope that it will become a most successful Branch.

NEW BYE-LAWS.—These are now in operation, and every Member will receive a copy of the same along with the Conference Booklet.

STATEMENT OF ACCOUNT AND BALANCE SHEET for the year ending December 31, 1923, are included in this Booklet.

OLIVER STUBBS, *President.*
W. G. HOLLINWORTH, *General Secretary.*

Balance Sheet.

INCOME & EXPENDITURE ACCOUNT.

EXPENDITURE.

	£	s.	d.
Postages	84	8	2
Printing and Stationery, including Printing of Proceedings	585	10	9
Council, Finance and Annual Meeting Expenses	74	3	11
Certificates and Diplomas	45	8	6
Illuminated Address	10	10	0
Branch Expenses—			
Lancashire 81 7 9			
Birmingham 39 10 10			
Scottish 60 17 2			
Sheffield 69 19 3			
London 85 5 6			
East Midlands 29 4 3			
Newcastle 88 19 10			
Coventry 52 6 11			
West Riding of Yorkshire 34 1 9			
	541	13	3
Audit Fee	6	6	0
Incidental Expenses	24	10	6
Salaries: Secretary and Staff	400	0	0
Rent of Office	65	0	0
Depreciation of Furniture, etc.	6	12	9
Grant to Branches for Entertainment—			
American Delegation 125 0 0			
Less: Amount refunded 11 0 9			
	113	19	3
	£1,958	3	1

(*Continued on page* 493.)

The Production of Castings in Permanent Moulds.*

American Exchange Paper.

By Robert J. Anderson† and M. Edward Boyd.‡

(*Continued from page* 468.)

Any alloy and almost any type of part can be cast in a permanent mould as in a sand mould, and of the various casting processes involving the use of metallic or permanent-type moulds, this has the greatest scope and widest possible applications. The process cannot, of course, be considered for small lots of castings, nor for complicated castings with severe coring, so that for jobbing work and the production of large and complicated castings the sand foundry will always maintain its place in both ferrous and non-ferrous alloys.

Principles of the Permanent-Mould Process.

The process of making castings in permanent moulds, irrespective of the alloy and the type of moulds, consists essentially in pouring the liquid alloy into the previously heated and assembled mould, dissembling the mould as soon as the alloy has frozen, and then removing the casting. The mould is then re-assembled and is ready for another pour. In operation, the mould is first heated, and kept at a suitable temperature by the application of external heat, and the various parts are clamped tightly together, the alloy being poured as in sand practice. The casting freezes almost immediately, the core—if of metal—is withdrawn, and the mould is parted, allowing ejection of the casting. As stated in another place by the writers[5b], the following three items are essential for the successful production of permanent-mould castings, viz.:—(1) A metallic mould which will withstand the action of the liquid alloy as well as rapid changes in temperature; (2) an alloy suitable for casting; and (3) a design of mould and casting and a method of gating which will ensure the production of good sound castings. In applying the permanent-mould process to the production of castings in specific alloys, especial consideration is to be given to the characteristics of the alloys, and this matter is dealt with at further length in a later section of the Paper.

There are a number of important factors governing the successful production of good permanent-mould castings with a minimum of wasters, and the following may be taken as the most important:—(1) Temperature of the mould; (2) pouring temperature of the alloy; (3) speed of operation, *i.e.*, number of castings poured per unit of time; (4) order in which core pieces are removed, if collapsible steel cores are employed; and (5) the size and location of gates, risers, feeders, vents, etc., *i.e.*, the method of moulding. The effects of these factors upon mould operation in the production of aluminium-alloy pistons have been discussed by the writers[5b] in another place, and the principles there elucidated are applicable in general to the production of most kinds of castings in various alloys.

The fundamental principles upon which permanent moulds are built and operated are substantially the same, and Székely* has patented the general principles of permanent-mould casting.[2] Many improvements have been made, however, in the past ten years, particularly in the construction and operation of moulds for the production of specific kinds of castings. Referring to the Székely patent, Figs. 8 to 11 inclusive show a form of permanent mould. Fig. 8 is a plan of the closed mould, which is made up in seven parts; Fig. 9 is an end view of the mould; Fig. 10 is a front elevation as seen from the left of Fig. 9; and Fig. 11 is a plan showing the mould thrown open. Referring to these figures, *c* in Fig. 11 designates the casting produced in the mould. The mould itself consists of a base, *1*, movable sides, *2*, *2*, movable ends, *3*, *3*, and movable top plates, *4*, *4*. The mould sides, *2*, are slidable on the base and are moved thereon by screws, *5*, rotatable in nut bearings, *6*, on the base, and having crank-wheels, *7*. The mould ends, *3*, are also slidable on the base, and are operated by screws, *8*, rotating in nut bearings, *9*, on the base. The top plates, *4*, are hinged at *10* to the respective sides, *2*, and turn about these hinges, which connect the top plates to the respective mould sides, *2*. When the top plates are down in place, they are locked by means of swing bolts, *11*, which are hinged to the respective mould ends, *3*, and engage slotted lugs, *12*, on one of the plates, *4*. The swing bolts have a wheel nut. In one of the top plates there is an outlet, *14*, for the gases from the mould. Suitable core recesses are provided in the mould to suit the particular object being cast.

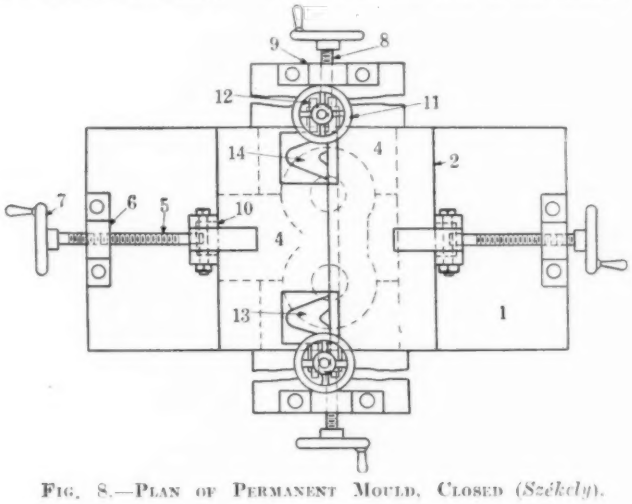


FIG. 8.—PLAN OF PERMANENT MOULD, CLOSED (*Székely*).

In the operation of casting, the sections of the mould are separated, the cores are set, and the interior surfaces of the mould coated with a suitable wash. The mould sections are then brought together by means of the screws, as in Fig. 8, and the liquid alloy is poured into the gate, *13*, until it appears at the riser, *14*. After the alloy has time to freeze so as to take the form of the mould, the mould is thrown open. The time during which the casting remains in the mould is about 20 secs. The mould is opened by first releasing the top plates, *4*, and turning them back on their hinges,

* Published by permission of the Director—U.S. Bureau of Mines, and read before the Newcastle Conference of the Institute of British Foundrymen.

† Metallurgist, U.S. Bureau of Mines, Experiment Sta., Pittsburgh, Pa.

‡ Formerly Asst. Metallurgist, U.S. Bureau of Mines, Experiment Sta., Pittsburgh, Pa.

* U.S. Patent No. 841,279. January 15, 1907.

and then running back the mould sides *2* and mould ends *3* by means of their respective screws. This is the position of the parts seen in Fig. 11, and it leaves the casting free from confining pressure or contact with the mould on all sides and at the top.

The mould described in Figs. 8 to 11 inclusive is for casting a rather irregular, intricate, and hollow pump section in cast iron or steel. In carrying out the process of Székely, it is specified that the mould is opened as soon as the surface of the casting shell has frozen sufficiently to retain the shape of the cavity, and a suitable wash or coating is specified for application to the cavity surfaces. In this mould, a sand core is used, but collapsible steel cores can be applied.

In the operation of most types of permanent moulds, the proper relation between mould temperatures, pouring temperatures, and gating must be worked out to ensure the production of sound castings with a minimum of wasters.

Some Typical Examples of Permanent Moulds.

As pointed out previously, the three requisites for successful permanent-mould casting are as follows, viz.:—(1) A suitable mould from the point of view of the material employed for the body of the mould and for the core, and from the point of view of design; (2) a suitable alloy; and (3) a suitable design of casting. Since a different type of mould can be employed for every type of casting produced, it is useless to describe many types, but since the fundamental principles upon which permanent moulds are built and operated are the same, description of a few typical moulds will be sufficient for present purposes. Moulds may be entirely hand operated, semi-automatic, or practically entirely automatic, and in the automatic type of moulds mechanical devices are employed for opening and shutting the moulds. Cores are normally set by hand in most types of moulds, but in permanent moulds for casting pipe-fittings[8] they may be operated mechanically. In permanent-mould work, the casting impression of the mould must necessarily be larger than the desired finished casting, so as to allow for contraction, and the exact contraction allowance is dependent upon the alloy employed. A gate or gates must be provided in the mould for pouring, and suitable risers and vents are cut to permit feeding the cast and to permit the escape of air and gases, thereby preventing blowholes. In permanent moulds, the moulds are designed and constructed in sections, having in view the fact that, after a casting is poured, the cores must be removed if collapsible steel cores are employed, and the mould parted rapidly so as to prevent the casting from contracting on the core or around projections in the mould-cavity, and thus cause cracking.

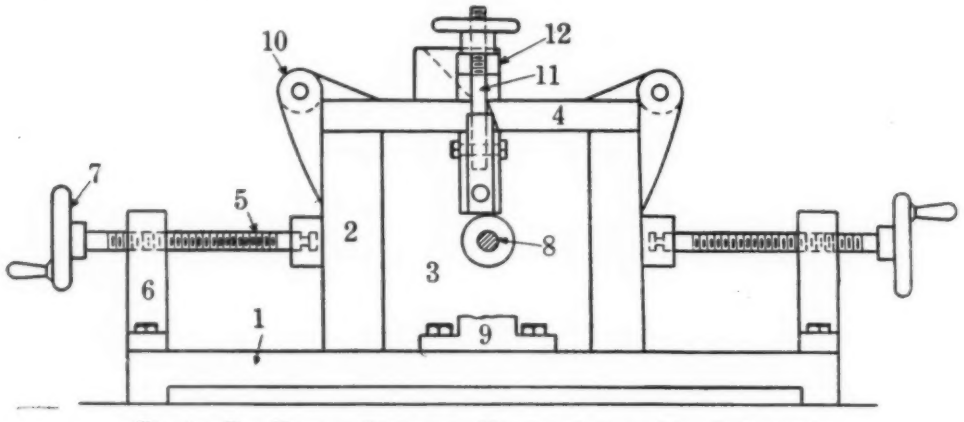


FIG. 9.—END VIEW OF PERMANENT MOULD SHOWN IN FIG. 8 (*Székely*).

As indicated, there are many types of permanent moulds employed for particular kinds of castings, but only a few of these can be described here.

Types of Moulds.

The shape of the casting to be made, and its size, as well as the coring necessary, determine to some extent the type of mould to be employed in permanent-mould casting practice. Generally speaking, there are about four basic types of moulds, each one adapted to meet the requirements in making specific castings most practically and economically. Typical moulds are described below, and the first three types are substantially the same as those used for aluminium-alloy piston production.[9]

In the first type of mould, the mould body proper is constructed of two halves or of several sections mounted upon a flat base plate which forms part of the casting and is essentially the bottom of the mould. Where the body is made of two halves, these may be hinged together and slidably parted, or else they may ride to and fro upon a track. The halves contain the mould impression and the gates and runners, and these cavities may be cut in only one of the halves or both. For flat castings, the cavity is usually cut in one-half. Fig. 12 shows a mould of the first type built upon a base plate that serves to form part of the casting, and in this mould the body proper is built up of several sections, and the largest section is fixed in position upon the base plate. The parting is not equi-axed with respect to the mould body, but the irregular sections

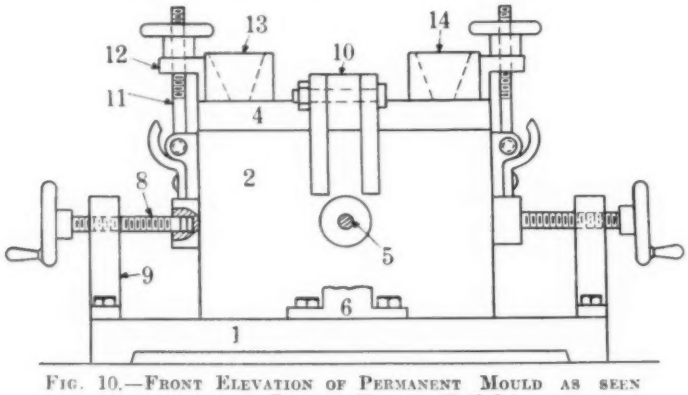


FIG. 10.—FRONT ELEVATION OF PERMANENT MOULD AS SEEN FROM THE LEFT OF FIG. 9 (*Székely*).

(Fig. 13) are simply lifted out when the mould is dissembled. Fig. 12 shows the mould assembled and ready for pouring, while Fig. 13 shows the mould dissembled. This particular mould is used in French practice[42] for casting dynamo-starter castings in aluminium alloys.

In the second type of mould the body proper consists of two halves, which are slidably mounted upon a flat base plate, which is simply a mounting and not used as part of the cavity proper. The

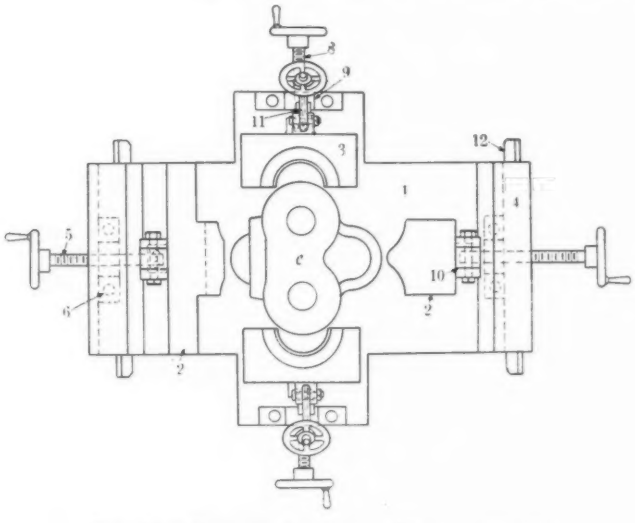


FIG. 11.—PLAN OF PERMANENT MOULD, THROWN OPEN; *cf.* FIG. 8 (*Székely*).

mould halves are actuated by levers for parting and closing, and the halves are held in alignment by dowel pins or by a clamp and lock. The halves may either be hinged together or else ride upon a track, and the hinged type is more usual. Normally, the casting-cavity and the gates and runners are cut in both halves, but the gating cuts may be in only one of the halves. In such moulds the casting cavity is usually equi-axed with respect to the line of parting. In this type, when using the hinge arrangement, a flat, smooth surface is required upon which the halves will slide easily, while with the track arrangement the halves may be actuated on a rack, or by means of a worm screw, much in the same manner that a vice is opened and closed.

Fig. 14 shows a detail drawing of a mould of the second type. This mould was employed in England during the late war for casting aluminium-alloy packing-pieces for aeroplane-struts. The mould consists of the two halves, *1*, *1*, dowelled together and hinged around the stud, *7*, which is fixed to the base standard, *3*. The mould-cavity is equi-axed with respect to the mould parting, and the two inserts, *4*, *4*, are fitted to fill up the planed slots (section XX). These two inserts are screwed into position, but the screws are not shown in the drawing. This method of making the mould is adopted to simplify the machining operations. Runner blocks, *2*, *2*, are also screwed to the mould halves; here also, the screws are not shown in the drawing. The core, *5*, forms the slot in the casting and is riveted to lever, *10*, which moves on fulcrum, *9*, for raising and lowering the core. When core, *5*, is in position, it is retained by core pin, *11*, which forms the hole in the casting. The two handles, *12*, *12*, are for opening and closing the mould. The small diagram in the upper right-hand corner of the figure shows the finished casting.

Fig. 15 is a detail drawing[43] of another mould of the second type. This was used in England for casting small gear-wheels in a zinc-base alloy, but the same mould could be used for aluminium alloys.

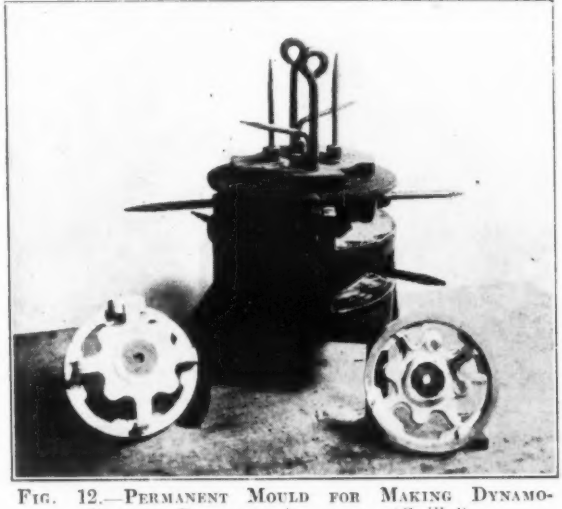


FIG. 12.—PERMANENT MOULD FOR MAKING DYNAMO-STARTER CASTINGS, ASSEMBLED (*Guillet*).

The mould consists of two runner blocks, *1*, *1*, fitted with handles and hinged around the stud, *5*, which is screwed to the base plate, *2*. The base plate is screwed to the base standard, *3*. The two runner blocks form the upper boss, or hub, of the wheel, and are held in contiguity by the stop pin, *6*. The ring, *4*, is set in the base plate, and forms the teeth of the gear wheel, this ring having the reverse impression of the gear teeth cut on the inside diameter. The other hub of the gear is formed in the base plate. The core pins, *7*, of which there are four, and the single core pin, *8*,

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are made to sliding fit in *2* and *3*, all being operated by shank, *10*, as in the mould shown in Fig. 14.

In the third type of mould the body proper consists of two halves, which are mounted upon a vertical arm so that one of the halves may be swung to and fro in the manner of a fence gate. The casting-cavity may be cut in one or both halves, as may be the runners and gates, but all cavities are normally cut in both halves, and preferably equi-axed with respect to the line of parting. Moulds

FIG. 13.—PERMANENT MOULD FOR MAKING DYNAMO-STARTER CASTINGS DISSEMBLED; *cf.* FIG. 12 (*Guillet*).

of the third type have been developed by Custer and used for making cast-iron pipe fittings, such as T and Y sections.

In the fourth type of mould, the body proper consists of two halves one of which is fixed in position on a suitable mounting, and the other is actuated mechanically for opening and closing the mould. The movable half may be slidably mounted upon rods or in other suitable way, and the movement is transmitted through gears and cams. Such a mould may be operated individually, but it is preferably set up as a battery on a revolving table. Six to twelve of such moulds may be mounted on a revolving table, and the pouring is done at one

moulds become more elaborate, and sometimes require two or more partings and intricate cores that slide into the mould halves. Usually this type of mould is mounted upon a heavy base plate and rides upon tracks, the mould sections being actuated by means of a worm screw. In moulds of this type it is common to have a stationary middle section, with two movable sections working against it. The degree of mechanical perfection attained is, of course, dependent upon the ingenuity of the mould designer. With individual moulds, if very large, two or more operators are required, but for small work mechanical devices make it possible for one man to operate a mould.

The question of cast-iron moulds for pouring rolling ingots in steel and non-ferrous alloys need not be discussed here, and while mention has not been made hitherto of plaster-of-paris moulds, a word on these latter may not be out of place in passing. Plaster-of-paris moulds are used to some extent for producing brass castings with a fine surface finish,[32] and such castings have the appearance of die castings or permanent-mould castings. Alloys cast in plaster-of-paris moulds are porous and unsound, and these moulds are not permanent

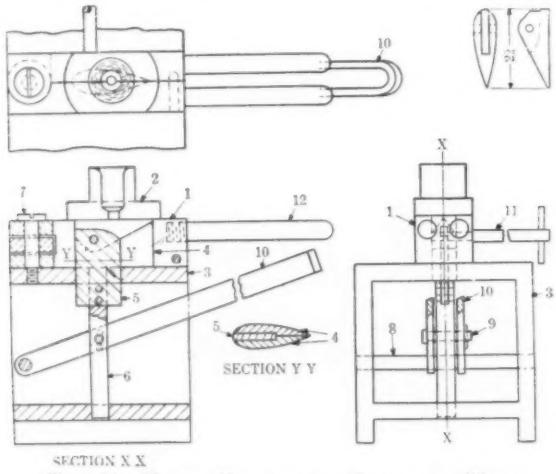

FIG. 14.—DETAIL DRAWING OF PERMANENT MOULD FOR CASTING PACKING PIECES FOR AEROPLANE STRUTS. (*The Metal Ind.*)

point from a platform, the operator remaining stationary. Such an arrangement is illustrated in photographs shown in Moldenke's Paper,[49] which show mechanically-operated mould tables employed at the plant of the Holley Carburettor Company, Detroit, Mich., for casting cast-iron carburettors. A sand core is used in these moulds. The moulds open mechanically on rotation of the table after a suitable short interval of time after pouring, the castings are ejected, and the moulds are then closed mechanically. By such an arrangement it is possible to increase the rate of production very markedly over hand-operated moulds.

For large and complicated castings, permanent

but destroyed on each pour. Castings poured in plaster-of-paris moulds are often referred to as permanent-mould castings because they have a good surface appearance, but the term is incorrect and misleading, and should not be applied.

Patent Moulds.

Very many patents have been taken out relating to the permanent-mould casting of alloys, but the confines of space prevent detailed discussion of this subject here. Although the idea of casting in permanent moulds goes back to 3,000 B.C., letters patent bearing on the process began to appear in the 19th century. The early patents dealt largely

with the casting of stereotype plates and similar castings. Two typical early patents are U.S. Pat. Nos. 213,427, January 22, 1878, and 314,395, November 30, 1883. Earlier patents are on record. With the opening of the 20th century a considerable number of patents began to be issued bearing upon every conceivable aspect of casting in permanent moulds. The moulds described are to be made of cast-iron, steel, and other metallic materials, abrasive mixtures, graphite, refractories, and what not, and claims are made for mechanical principles of operation, and for alloys to be cast. The numbers of a few United States patents relating to permanent-mould casting are given in Table I.

TABLE I.—*American Patents issued in connection with Permanent-Mould Casting.*

U.S. Pat. No.	Date.	U.S. Pat. No.	Date.
695,091	Mar. 11, 1902	1,097,847	Oct. 26, 1910
714,061	Jan. 2, 1902	1,104,037	Oct. 22, 1910
841,279	Jan. 15, 1907	1,019,905	Mar. 12, 1912
859,612	July 9, 1907	1,360,655	Nov. 30, 1920
904,759	Mar. 3, 1908	1,368 445	Feb. 15, 1921
1,042,092	June 3, 1910	1,410,776	Mar. 28, 1922

A list of United States patents on the permanent-mould casting of aluminium-alloy pistons has been given by the writers[50] in another Paper.

of semi-steel does, however, seem to yield longer life and less distortion than ordinary grey iron.

A satisfactory composition is stated to be as follows:—Combined carbon, 0.13; graphitic carbon, 2.98; silicon, 2.15; sulphur, 0.086; phosphorus, 1.26; and manganese, 0.41 per cent. Other analyses are given in another Paper by the writers.[50]

Grey iron moulds, particularly when used for pouring alloys melting above 600 deg. C., may warp, grow, and become distorted in service, and such growth and distortion are very markedly affected by the silicon-content of the iron. Rugan and Carpenter[4 12 14 25] have shown that the direct cause of growth of grey iron is due to the expansive force exerted by the oxidation of iron silicide, and the gases nitrogen and hydrogen increase growth when the silicon-content of the iron is between 1 and 3 per cent. Phosphorus, manganese, and sulphur in increasing amounts tend to diminish growth, and the results of all experiments made to date show that the growth of grey iron on repeated heating and cooling is a direct function of the silicon-content. However, unless graphite is present, silicon of itself is innocuous. Since the solution of growth difficulties lies in using material which contains no free carbon, and further, does not deposit carbon on heating, this rules out all grey irons and many white irons. White irons are,

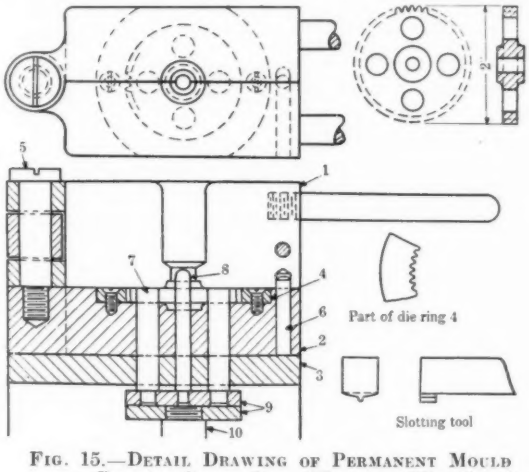

FIG. 15.—DETAIL DRAWING OF PERMANENT MOULD FOR CASTING SMALL GEAR WHEEL. (*The Metal Ind.*)

Table II gives a few patent references to permanent-mould casting issued in other countries.

TABLE II.—*Patents other than American issued in connection with Permanent-Mould Casting.*

Country.	Pat. No.	Date.
Germany..	119,643	Jan. 16, 1900
France	338,645	Nov. 13, 1903
France	479,158	Feb. 28, 1916
England	105,101	Mar. 29, 1916
England	192,978	April 11, 1923

Materials for Moulds and Cores.

Materials for Moulds.

Materials for constructing permanent moulds are rather limited, the more readily available being cast iron, steels of various kinds, nichrome, and malleable iron. Such materials as graphite and various refractory substances have been employed, but these have very definite limitations. Grey cast iron is a suitable material, and is much easier to shape and machine than is steel, particularly alloy steel. Mild steel has been employed satisfactorily, whilst semi-steel and malleable iron have been used to a less extent. Alloy steels such as used for die-casting dies are expensive, and the general tendency in permanent-mould construction is to employ grey cast iron. There has been considerable discussion as to the best composition of cast iron for use in permanent moulds for non-ferrous alloy casting, but the writers are inclined to believe that this has been over-emphasised, since very satisfactory results have been secured using ordinary run of foundry iron. Close-grained iron of the order of course, unmachineable, and they almost always crack on heating, so that the only alternative in ferrous materials is to employ steels. The actual amount of growth in grey iron on repeated and prolonged heating may be 15 to 37 per cent. for silicon-contents of 1 to 3.5 per cent. respectively. Carpenter[12] states that an iron alloy containing carbon, 3.0; silicon, 0.6 to 0.7; and manganese, 0.5 per cent., does not grow, while one containing carbon, 2.5; manganese, 1.5; silicon, 0.50; and 0.10 per cent. each of sulphur and phosphorus contracts about 0.4 per cent. after repeated heating. Objection has been made by some to high-phosphorus-content on the ground that the iron-phosphorus eutectic has a low melting-point. The phosphorus in grey irons is usually present as a ternary eutectic, containing iron, 91.20; carbon, 2.0; phosphorus, 6.80 per cent., and the melting-point of ordinary grey iron is reduced about 27 deg. C. for each per cent. of phosphorus present.

Generally speaking, the life of a grey-iron mould is dependent not so much upon the number of castings poured as upon the number of times it is allowed to cool to the ordinary temperature. The growth of cast iron is accelerated by heating and cooling, and the strains set up by such treatment are more destructive than the erosive effect of the liquid alloys. It has been estimated that a mould used continuously will outlast four moulds used only at fairly frequent intervals. Usually, the gates and risers are the first points to show signs of disintegration, although some moulds have been reported as being in service as long as five years and in good condition. Frequently, however, it is necessary to renew the gates and runners by blocking in with new iron and re-cutting the cavities.

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Refractory-lined Moulds.

Many attempts have been made, more or less successfully, to apply refractory coatings and washes to the mould-cavity surface in grey iron for the purpose of preventing erosion of the mould and so that steel castings could be made. In general, coatings that are easy to apply are unstable, and those that are most refractory will not adhere to the face of the mould. In British practice for casting both ferrous and non-ferrous alloys a number of washes and dressings have been used, including seal oil, lard oil, linseed oil, tallow, etc., mixed with graphite. Where carbonaceous dressings are not desired, Johnson[48] recommends an emulsion of bone-ash and water, and he also suggests a dressing made by burning a smoky flame against the mould surface—this depositing amorphous carbon. A mixture of lime and sodium silicate or of refractory clay and sodium silicate has been employed in American practice. Washes of alundum, carborundum, and various other refractories have been tried.

In the matter of refractory-lined moulds it is of importance to direct attention to the method of lining cast-iron moulds for pouring cast-iron castings, as devised and patented by Meloche* and used by the Holley Carburettor Company. The method, so far as is known to the writers, is unique, and details are given of the application of the lining method by Moldenke.[49] In this coating method a thin wash of a mixture of sodium silicate and fireclay is brushed on the mould (heated to about 175 deg. C.), several coats being applied so that a moderate thickness is secured. Each coat is baked on before the next one is applied. This refractory coating is covered and protected by a layer of lampblack (amorphous carbon), deposited by burning an acetylene flame upon the refractory coating. The mould proper is made of two light grey cast-iron halves. It is of interest to state that easily machineable, unchilled cast-iron castings are made in this type of mould. This method appears to be capable of great development and to have many possible applications in the production of both ferrous and non-ferrous castings.

Material for Cores.

Cores for permanent-mould casting may be made of sand, as in ordinary sand-casting practice, or of steel or cast iron. Sand cores are used to a considerable extent for both ferrous and non-ferrous castings, particularly in the case of complicated coring, but collapsible steel cores are employed for certain types of castings. Simple cylindrical cores of cast iron are used for hollow castings, *e.g.*, pipe fittings. Cast-iron cores are usually employed in pouring cast-iron casting when the internal shape permits, without the use of a collapsible core, while in other cases sand cores must be employed. Steel and wrought-iron cores are less satisfactory than cast-iron cores for pouring iron. Alloy steel, such as chrome-vanadium steel and high-speed tungsten steel, is satisfactory for non-ferrous alloys, but mild steel has also been used. Alloy steel cores are considerably more expensive and more difficult to shape and machine than ordinary steels, but they withstand usage much better

Design and Preparation of Moulds, and Methods of Gating.

Irrespective of the materials employed for constructing moulds and cores in permanent-mould work and of the alloy cast, the problems of design are essentially the same. The general aspects of mould design in the case of aluminium-alloy piston moulds have been discussed at length by the present writers[50] in another Paper, and the general remarks there made are applicable to the permanent-mould process as a whole. In the present Paper the question of mould-design will be treated only in a very general way. Each type of casting to be made in a permanent mould presents a separate problem of itself and no general rules can be laid down to ensure successful casting. In general, a certain amount of experimental work, particularly in connection with gating, may be necessary with a new mould. There are, however, certain fundamental principles that may be followed to advantage.

The first item for consideration is the relation of the size and thickness of the mould body to that of the casting produced. Mould-wall-thickness and size of the mould is governed by the thickness of the casting, the object in non-ferrous alloys being to produce a chilling effect upon the casting. In the case of grey cast iron, chilling is to be avoided, and this is accomplished either by pouring very hot moulds and removing the casting rapidly, or else by employing an insulating refractory lining, as in the type of mould used by the Holley Carburettor Company. Regulation of chilling effect in non-ferrous alloys is also had by varying the mould temperature and the pouring temperature. For an aluminium-alloy casting the size of a 4-in. dia. motor piston, the mould-wall thickness is ½ in. to ¾ in., and larger castings may require thicker moulds. Moulds with too thin walls warp readily and do not permit maintenance of uniform temperatures; consequently it is better to have the mould too heavy than too light. At the same time, in the case of hand-actuated moulds, heavy moulds are more difficult to operate. The shape of the mould body will depend in general upon the shape of the part to be cast, although the general tendency is to make simple geometrical shapes, having square, rectangular, or circular cross sections.

The same general principles of design apply in the construction of permanent moulds for both ferrous and non-ferrous casting, although generally the surface of the casting cavity when pouring cast iron need not be so smooth as for brass or aluminium alloys since ordinarily the finish on iron-work does not need to be as good. Moulds for pouring cast iron should be thicker than for non-ferrous alloys in order to resist better the effect of higher temperatures in causing warping. Heavier moulds must, obviously, be equipped with better fittings. The pouring temperature for any alloy cast in a permanent mould is higher than when casting in sand moulds.

In many types of permanent moulds no ejector pins are used for removing the frozen castings, and consequently the castings may stick to the mould, particularly if the mould surface is rough. Generally speaking, it is best to provide ejector pins. Moulds may be difficult of operation because of the draft or of many core pieces which must be placed before each casting is poured, and the removal of castings from a permanent mould normally takes longer than from a die in die casting. The joints between mould sections should be perfect, since otherwise small fins of metal are formed on the casting, which may prevent rapid ejection. The question of mould operation and the gating and design of moulds in the case of aluminium-alloy piston production have been discussed at length by the writers[50] in another place, and the fundamental principles there given are applicable to permanent-mould casting in general.

Gating of Moulds.

Generally speaking, no definite method of mould gating can be described, since each casting requires separate consideration. The position of gates and risers on castings of simple and regular form is not specially important, but where account must be taken of bosses, webs, lugs, flanges, and other irregularities, the best general plan is to gate close to the thickest section and provide small risers near other heavy sections. This rule is, however, far from invariable, much depending upon the shape of the casting. Often the casting must be placed in a certain position in the mould, and this prevents gating at the most advantageous points.

There is great difference of opinion among mould designers as to the best type of gate to employ, some preferring bottom- or side-feeding gates, while others use a simple top-feeding gate. The present writers have tried various methods of gating, and believe that a gate which feeds along the side or near the top of the mould is more satisfactory. It has been the writers' experience that with bottom-feeding moulds the first-deposited and partly-chilled alloy is forced up into the mould cavity by the rush of hot alloy behind it, and such first-deposited alloy is never really sufficiently fluid to fill out the cavity, the result being cold shuts or overlaps. The object to be attained in gating is, of course, the adequate filling of the mould cavity with as little disturbance or splashing of the liquid alloy as is possible. In some cases it is not possible to determine the proper gating until the mould

* U.S. Pat. No. 1,453,593, May 1, 1923.

is actually tried by pouring castings with some method of gating. Generally it is good practice to decide on a method of gating and then cut the gates and runners obviously too small; these cavities can then be enlarged as required.

During preliminary "try-out" of the mould it may be observed that certain areas of the casting do not fill out, or that draws occur at some points. These defects are usually remedied by attaching small shrink pads to the casting, these pads being connected by narrow feeders. If the defective spots are so situated that this method cannot be applied, the head of alloy in the gate may be increased. In casting alloys having high contraction in volume, cracks may occur at the juncture of thick and thin sections, and chills may be placed in the mould in contact with the thick section in order to increase its rate of cooling. Such chills in an iron mould may be made of brass or copper, which have greater thermal conductivity than the iron.

Coring.

As stated previously, both sand and metallic (cast-iron or steel) cores are employed in permanent moulds, and the type of core used depends upon the nature of the casting poured and the alloy used. Where sand cores are employed, the method of casting is often referred to as casting in semi-permanent moulds. Generally speaking, sand cores are used for casting ferrous alloys and steel or iron cores for non-ferrous, but both kinds of cores are used for the different classes of alloys. Sand cores are used where the coring is complicated, and where too many core pieces would be required in the construction of a collapsible steel core. In the case of steel cores, if the casting is of simple design, it is sometimes possible to construct the core in one piece, but in many castings undercuts are encountered, so that irregular coring is required, and this necessitates using a collapsible core made up of several pieces. The principle involved in constructing a collapsible core is the same as that followed in making collapsible mandrels for spinning metal hollow-ware. Cases of undercuts are handled by using a central core piece around which the actual interior contour of the casting is formed by additional core pieces. This method permits withdrawal of the outer core pieces from the mould after the centre core piece has been removed. A collapsible steel core for aluminium-alloy piston castings is shown in Fig. 15 of the Paper on the production of aluminium-alloy pistons in permanent moulds by the writers.[10] With collapsible steel cores, a taper of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. per ft. is allowed in order to permit easy removal from the mould.

While sand cores are used for making various types of castings in permanent moulds, they present several disadvantages, particularly when non-ferrous alloys are cast. Care must be exercised in placing sand cores, and they should be heated before being inserted into the mould. Sand cores do not give so good surface finish to the interior of a casting as steel cores, and for some classes of work this makes them undesirable. Moreover, castings made with sand cores are not so accurate.

Venting.

Permanent moulds may be vented by cutting small grooves $\frac{1}{32}$ in. to $\frac{1}{8}$ in. wide and 0.004 in. or more deep, across the core and mould joints from points which appear to require special venting. Simple castings are, as a rule, sufficiently vented by risers. Of course, loose cores and joint faces greatly aid venting.

Machining.

In preparing a permanent mould, it is advantageous from the point of view of economy in machining to construct the mould pattern so as to conform as nearly as possible to the desired finished mould. The cavity may then be finished by a minimum of machining. Details of machining need not be given here, but it may be emphasised that the important features to be considered, outside of gating and the general aspects of mould design, are the obtaining of a smooth surface finish to the casting cavity and making the proper allowance for contraction. There are so many factors affecting the contraction of the casting that no specific rules can be laid down to ensure the casting coming out to "dead size" at the first trial. It is customary to allow 0.1 per cent. for aluminium alloys in general, 0.07 per cent. for brass, and 0.05 per cent. for zinc alloys

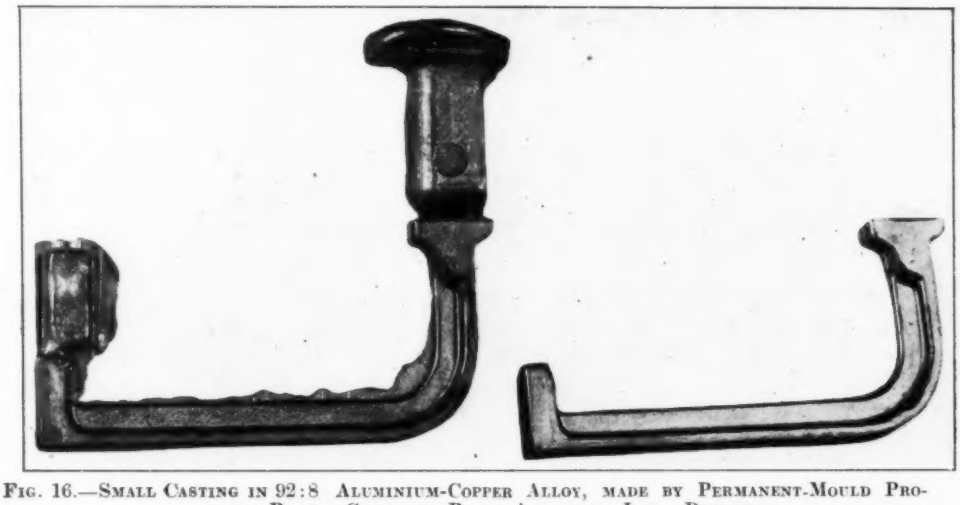

FIG. 16.—SMALL CASTING IN 92:8 ALUMINIUM-COPPER ALLOY, MADE BY PERMANENT-MOULD PROCESS; RIGHT, GATE AND RISER ATTACHED; LEFT, DRESSED.

Alloys Used and Types of Castings Made.

Like other casting processes, the process of casting metals and alloys in permanent moulds is restricted in its applications by certain inherent limitations. Obviously, better results can be obtained with certain alloys and upon certain types of castings. As pointed out previously, only castings that may be classed as repetition work and that are required in large numbers can be economically cast in permanent moulds. Thus, at the outset, the process is limited by economic considerations. At the present time, the commercial application of permanent-mould casting to non-ferrous work is restricted to a few alloys, but it may be expected that the process will be extended to all kinds of non-ferrous alloys. The applications of the process to several types of alloys are discussed briefly below.

Aluminium Alloys.

In the non-ferrous field, the permanent-mould process has been largely applied to the production of aluminium-alloy castings. The requirements of the automotive industry for miscellaneous castings in aluminium alloys offer a particularly adaptable field for permanent-mould casting, since these castings are required in large numbers. For this class of work there are distinct advantages in the process, since the castings can be made rapidly, have a good finish, and require little machining. The tensile properties of the aluminium alloys are considerably better when chill-cast than sand-cast, and aluminium alloys when poured in permanent moulds are sound. Die-cast aluminium alloys are

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very porous and unsound, and sand-cast alloys are also likely to be unsound.

Among other castings, pistons, instrument panels, brake-shoe arms, door handles, small gear-housings, steering-wheel spiders, small hardware, and other parts are now cast commercially in aluminium alloys in permanent moulds. Small castings for electrical equipment are poured in permanent moulds, and larger castings, such as gear-housings, and crank-cases, weighing 20 to 150 lbs., have been cast. Aluminium-alloy automobile wheels have been successfully cast in permanent moulds, but such wheels have not so far been employed to any extent. There are many specific castings in aluminium alloys which are now being sand-cast or die-cast which are better suited to the permanent-mould process from the point of view of soundness, mechanical properties, and production. Commercially, the maximum weight of permanent-mould castings made in aluminium alloys is about 25 lbs., and the minimum weight is 1 oz., although castings weighing up to 200 lbs. have been made. The minimum section thickness in permanent-mould castings of aluminium alloys is $\frac{1}{8}$ in. The limit of accuracy to which castings may be made is about $\pm$ 0.010 in. Unless the casting is small and of simple design, difficulty is sometimes encountered in keeping within close size limits, due to uneven contraction caused by variation in section sizes in the part. Where machining is to be done on the casting, the limits usually worked are $\frac{1}{32}$ in. to $\frac{1}{16}$ in.; for long cored holes it is usual to provide a slight taper, which can be corrected by a reaming operation. Weight tolerances on aluminium-alloy permanent-mould castings are $\pm$ 2 per cent.

Of aluminium-alloy automotive castings made in permanent moulds, pistons are cast in by far the greatest number. Some concerns make pistons solely. Piston production has been discussed by the present writers[59] in another Paper, and need not claim further attention here. Small castings in aluminium alloys may be gated with two or more together, and the rate of output greatly increased. Fig. 16 shows a small aluminium-alloy casting made by permanent-mould casting; at the left, the pouring gate and riser are attached, while at the right the casting has been trimmed. Fig. 17 shows an instrument panel, for a motor car, with gates and riser attached. Various aluminium alloys are employed for permanent-mould castings, including the ordinary 92:8 aluminium-copper alloy and other aluminium-copper alloys containing 4 to 14 per cent. copper. Certain special alloys are also employed, including silicon-bearing aluminium alloys, nickel-bearing aluminium alloys, and aluminium-copper-magnesium alloys. Little work has been done to develop the most suitable aluminium alloys for permanent-mould casting, aside from piston alloys. At the present time the most suitable composition of aluminium alloy for permanent-mould work is a matter of considerable conjecture, but it should be well-fluid at moderate temperature above the melting-point and have small contraction, little solvent action upon the mould, and good strength at elevated temperatures in the solid state.

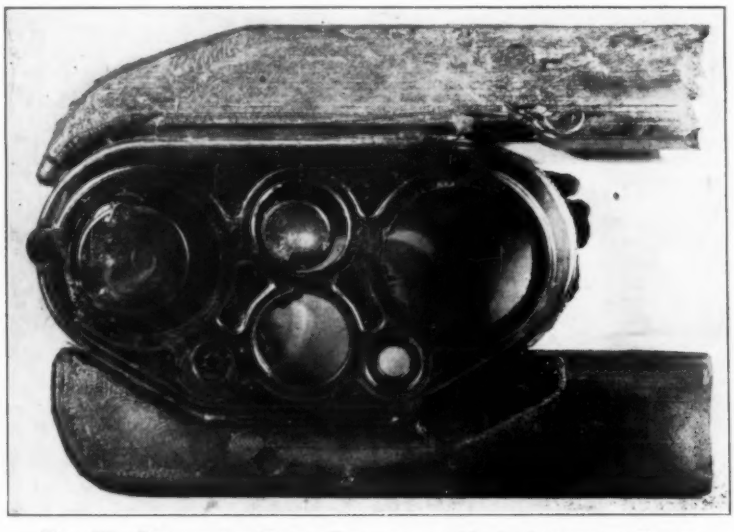

FIG. 17.—INSTRUMENT PANEL CASTING IN 92:8 ALUMINIUM-COPPER ALLOY, MADE BY PERMANENT-MOULD PROCESS; GATE AND RISER ATTACHED.

Copper Alloys.

Small castings in 67:33 brass and similar alloys can be successfully cast in permanent moulds. The fairly-high melting-temperature and corrosive action of these alloys have a deteriorating effect upon cast-iron moulds, however, and the moulds become inaccurate after 2,000 to 3,000 castings are poured. For this reason, unless considerable saving is effected in machining costs and from increased rate of production, these alloys are better cast in sand. High-zinc copper-alloys, especially at high temperatures, have very erosive action on iron, owing to the zinc, but alloys of the bronze type are not so erosive. Dynamo-brush holders, gear wheels, and various small castings have been made commercially in brasses in permanent moulds. Gun-metal and phosphor-bronze bars to be used in automatic-machine work for bushing and liners have been cast in permanent moulds. Bars $1\frac{1}{4}$ in. to 2 in. dia. and 3 ft. to 6 ft. long are used for this purpose. Aluminium bronze is cast commercially in permanent moulds, and gear wheels and small parts for electrical manufacturing are now being made. It is reported that gear wheels weighing 10 lbs. to 40 lbs. and with teeth cast of an accuracy of $\pm$ 0.001 in. are being produced. The life of cast-iron moulds when casting aluminium bronze ranges from 5,000 to 30,000 castings, according to reports.

White-Metal Alloys.

All sorts of white-metal alloys can be cast by the permanent-mould process, but in general the die-casting method is more suitable. Zinc castings, including gear wheels and "crows' feet" for wet-cells, are cast commercially. Permanent-mould casting is useful for these alloys when a white-metal alloy is to be cast on to cast-iron or steel bodies.

Iron Alloys.

In the iron trades, various articles are made by permanent-mould casting, including plough-points, brake shoes, soil pipe, pipe fittings, projectiles, colliery-tub wheels, bevel gears for agricultural machinery, grate bars, hammer blocks, etc. Most of these articles are cast in the ordinary run of foundry iron. Little work has so far been done in cast steel or semi-steel, but there seems to be no reason why these alloys should not be cast in permanent moulds. The development of the permanent-mould process for casting cast iron has been hindered by difficulties encountered in preventing excessive chilling of the iron. Various methods have been devised for overcoming the chill effect, including heating the mould, lining the mould

with refractory material, and annealing the chilled castings. Custer[3] has discussed the effect of permanent-mould casting upon the chill of cast iron, and in the process devised by him chilling is avoided by taking advantage of the fact that an interval of time elapses between the temperature at which the metal sets and that at which it begins to chill. This interval of time is sufficient to allow removal of the casting from the mould and avoid the chilling effect. The usual time during which the casting remains in the mould is 2 to 10 secs., depending upon its thickness. The most successful process involving refractory-lined moulds of which the writers have knowledge, is that used by the Holley Carburettor Company.[49]

Summary.

In this Paper the production of castings in permanent moulds is discussed in a general way, and the applications and limitations of the process to both ferrous and non-ferrous casting have been pointed out. The history of the permanent-mould process has been sketched briefly, it being pointed out that permanent types of moulds, including stone and bronze moulds, were used as long ago as 3,000 B.C. Typical examples of such old moulds are shown. The development of the permanent-mould process in recent years has been reviewed briefly.

It has been indicated that there are five separate and distinct casting processes involving the use of permanent or metallic moulds, viz.: (1) Die casting; (2) slush casting; (3) Cothias casting; (4) centrifugal casting; and (5) permanent-mould casting. These different casting processes are defined, and the first four are discussed briefly, and then compared with the true permanent-mould-casting process, which is the counterpart of sand casting. It is explained that the permanent-mould process is the same as the sand-casting process in method of operation, and the chief difference lies in the type of mould employed. The use of permanent moulds is desirable, since in sand practice each mould is destroyed on pouring, and a mould that can be used over and over again is required, especially in repetition work involving large numbers of castings.

The general principles of the permanent-mould process have been discussed, and a typical permanent mould is described as illustrative of these principles. Some typical examples of permanent moulds are described, and the four main types of moulds are discussed. It has been pointed out that very many patents have been issued for claims bearing on permanent-mould casting, and a short list of patents is given.

The question of materials employed for making moulds and cores is taken up, and it is pointed out that grey cast iron is used largely for the mould body proper, while both metallic (collapsible steel) cores and sand cores are employed. The growth and distortion of grey iron moulds in service is discussed briefly. The use of refractory linings and coatings for permanent moulds is discussed.

The design and preparation of moulds and methods of gating are taken up in a general way, and the main principles of mould preparation have been discussed.

Finally, the various types of alloys used commercially for casting in permanent moulds have been considered, and the types of castings made in these alloys have been described.

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THE WELSH MERCHANTS have formed an association under the title of the South Wales and Monmouthshire Association of Tinplate, Iron, Steel, Metal and Scrap Merchants (Scrap Section), with offices at the Royal Metal Exchange, Swansea. The association has become affiliated with the Federated Associations of Scrap Iron, Steel, Metals and Machinery Merchants of Great Britain.

THE TENDER of the Broken Hill Proprietary Company for the supply of 29,367 tons of 60-lb. rails and 2,241 tons of 60-lb. fishplates at an estimated cost of over £390,000 has been accepted by the South Australian Government. These rails and fishplates will be made at the company's steel works at Newcastle. The company was the lowest tenderer for delivery on the wharf at Port Adelaide. Referring to the letting of this contract, the Minister states: "It is very satisfactory to know that these rails and fishplates can be given to the Broken Hill Company with every confidence that they will carry out the contract in a satisfactory manner, and that, in competition with manufacturers in the Old Country, they can submit a tender at a price which is absolutely the lowest received."

XUM

Non-Ferrous Alloys in Marine Engineering—with Special Reference to Admiralty Gunmetal, Manganese Brass, and White Metals.*

By A. E. Logan.

INTRODUCTION.

Although the introduction of the turbine, and more recently the development and introduction of the Diesel engine, are outstanding events, progress in marine engineering has been to some extent a process of evolution. Demands for larger and faster vessels have been met by increases in engine size, and the use of higher boiler pressures and superheat. This, together with the continual striving after weight reduction, with its consequent decrease in section thickness, has naturally led to more exacting working conditions for the materials of construction.

Fifteen years ago, boiler pressures of 180 to 190 lbs. per sq. in. were usual, at temperatures of about 375 deg. F., and superheat was just being introduced for the second time. In present practice, pressures of 220 to 225 lbs. per sq. in. are quite common, with 250 deg. or more superheat; giving total steam temperatures of 650 deg. F. and over, and the tendency is to go still higher. Outward and visible evidence of this, and how it affects the foundry, is to be found in the fact that increased demands are being made in specifications. The most obvious instance being the raising of the Admiralty requirements: in the case of gunmetal, from 14 tons per sq. in. with 7 per cent. elongation, to 16 tons per sq. in. with 8 per cent. elongation. In the case of manganese brass, the specification now demands 33 tons per sq. in., and 15 per cent. elongation, and for cast iron, 11 tons per sq. in.

This is undoubtedly an indication of progress, and as such is to be welcomed; especially as it signifies that there has also been progress in foundry work generally.

The moral, however, should also be noted. Working stresses are increasing, and test figures are being raised, consequently working margins are reduced. The foundry must therefore take advantage of modern methods of efficiency, together with every aid of science. The foundryman who seeks to know more, can learn much from simple, practical experimental work in his own foundry, especially where a pyrometer is available. It is impossible to over-estimate the value of the pyrometer when used in this manner. It is obviously impossible to treat all the non-ferrous alloys used in marine engineering with any degree of completeness in one short paper, consequently attention is confined to one or two of the alloys in general use; namely, Admiralty gunmetal, manganese brass, and white-metal. It is hoped, by indicating the importance of structure from the practical point of view, to help those who handle these alloys towards a clearer understanding of their natures, and the reasons for the treatment they require.

Functions of Various Parts and Influence on Choice of Alloy.

In marine engineering, the parts dealt with can be roughly divided into three sections, excluding the Diesel, to which sections 2 and 3 only apply.

(1) The boilers, which are the source of energy.

(2) The engine, which may be either reciprocating, turbine, or Diesel, and which is the means of converting the energy into work.

(3) The transmission, or shafting and propellers (including the gears, if a geared turbine), which convert the work done by the engine into propulsive effort.

SECTION I.

Boiler Alloys.

In this section, very little of non-ferrous alloys are used—the boiler shell, tubes, etc., being of steel. Main stop valves are sometimes of gunmetal, but the tendency is to go in for cast steel bodies, to withstand the high temperatures and pressures of modern practice. Even so, it is often necessary to let rings of special alloys, such as Monel metal, into the valve seats. Gauges and similar fittings are usually of brass.

Of the actual engines, the turbine has by far the greatest proportion of non-ferrous alloys in its construction. Only moderately small amounts of non-ferrous alloys are employed in the reciprocating and Diesel engines, in merchant practice, at all events.

Admiralty gunmetal is greatly used for valves and steam fittings of all kinds, and in general constructional work, gunmetal, and phosphor bronze in

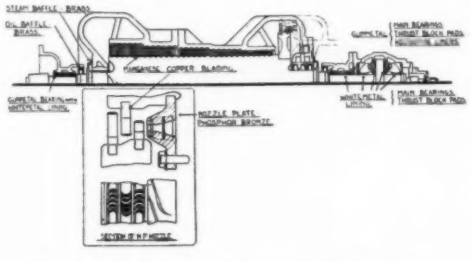

FIG. 1.—SECTION OF MARINE H.P. TURBINE.

particular, in addition are very useful as bearing metals, for a reason which is indicated later. Admiralty gunmetal is often used for such bearings as top end brasses, tail shaft liners, stern tube bushes, etc., and phosphor bronze for many other smaller bearings. In the turbine, such things as nozzles, and especially the first few rows of blades in the H.P. turbine, must possess strength at high temperature; and be tough or hard wearing, to resist the erosive action of the high velocity steam. Such alloys as 96.9 copper; 3 tin; and 0.1 per cent. phosphorus for nozzles, and manganese copper containing 3 to 4 per cent. manganese, for blading, are therefore used. (See Fig. 1.)

The main bearings of all types, and the crosshead guides, etc, of the reciprocating and Diesel engines, are lined with white metal. It is preferable that the bushes should be of gunmetal, as in the event of a "run out," less damage would pro-

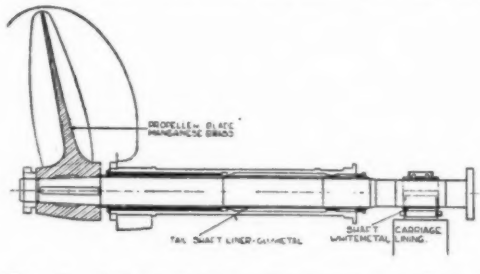

FIG. 2.—ARRANGEMENT OF PROPELLER AND STERN-TUBE.

bably result. Condensers are usually tubed with 70: 30, or 70 : 29 : 1 brass, but the great prevalence of corrosion trouble is clear indication that these materials are not satisfactory, but are only adhered to for want of a suitable alloy with the necessary immunity from corrosion, which can be as easily worked into tube form.

The propeller shaft is supported on white metalled carriages. The tail shaft, which actually carries the propeller, is cased in a shrunk-on gunmetal liner, and this in turn revolves in a stern bush, which is sometimes of gunmetal. All kinds of materials are used for the propeller itself, ranging from cast iron to steel and manganese brass. Manganese brass, although expensive, and some-

* Paper read before the Newcastle Conference of the Institute of British Foundrymen.

times not above trouble, due to erosion, is far superior as regards resistance to corrosion, and has a far longer life than either cast iron or steel. This, in conjunction with its increased efficiency, is held more than to outweigh its initial cost.

Bronzes.

The name gunmetal, whilst it is generally taken to mean something substantially a bronze, as generally used in engineering, is really a very vague term, and may mean anything from a brass with only a percentage or so of tin, to a composition like 85 per cent. copper and 15 per cent. tin. On the other hand, Admiralty gunmetal is the definite 88:10:2 mixture, which is so well known, and as a high-class, all-round-purpose alloy is difficult to improve upon. Attempts to cheapen this alloy for merchant work take the obvious form of reducing the tin and increasing the zinc, with possibly the addition of a little lead. An alloy on these lines, containing 86 copper, 8 tin, 2 lead, and 4 per cent. zinc, has been used with a fair amount of success for general work. Another similar composition is 87 copper, 8 tin, and 5 per cent. zinc, and bars cast on tail-shaft-liners of this latter composition have given as much as 20 tons per sq. in. with 35 per cent. elongation.

Admiralty Gunmetal.

The alloy known as Admiralty gunmetal has more or less established itself as a "standard" composition, and with perhaps a little latitude in the lead content, is often used—apart from Admiralty work—where a high-class, strong bronze is required. It might be remarked in passing that there seems no reason why 1 per cent. lead should not be allowed, even in Admiralty work; in fact, from some points of view, it would be a positive advantage. Admiralty gunmetal has been the subject of a large amount of research work, especially of recent years, and much has been published concerning it.

Equilibrium Diagram of the Copper-Tin Alloys.

As an aid to the more complete understanding of gunmetal, the equilibrium diagram, or that portion of it which includes up to 20 per cent. tin, should be considered. The equilibrium diagrams of the copper-tin and copper-zinc alloys are both

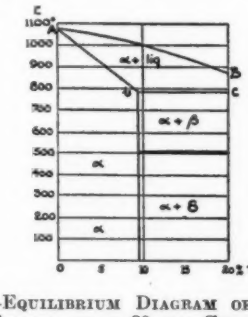

FIG. 3.—EQUILIBRIUM DIAGRAM OF THE COPPER-TIN ALLOYS UP TO 20 PER CENT. TIN. (FROM HEYCOCK & NEVILLE'S DIAGRAM.)

recommended for the study of the practical foundryman, as much may be learned from them alone. The equilibrium diagrams show the freezing points, and changes which take place on cooling, for any proportions of copper and tin or copper and zinc as the case may be.

In the case of the copper-tin alloys, starting with pure copper, which has a melting-point of 1,084 deg. C., and adding tin, the freezing-point is gradually lowered. The line A—B is known as the liquidus, and marks the commencement of solidification. At temperatures above this line, alloys are entirely liquid. The line A—b—c is known as the solidus, and indicates the completion of solidification. Any further line shown below the solidus must therefore relate to changes which take place in the solid alloy whilst cooling. Such a change is indicated in the diagram of the copper-tin alloys, and occurs at 500 deg. C. Alloys containing up to 9 per cent. tin exist as a solid solution of tin in copper, known as the alpha solid solution. In material as cast, this is not homogeneous, owing to the difference in the melting-points of copper and tin, which are 1,084 deg. C. and 232 deg. C. respectively. This causes relatively pure copper to separate out first. When between 9 and 23 per cent. tin is present, a second constituent known as beta is formed. At temperatures above 500 deg. C. the structure consists of the alpha and beta solid solutions. If the alloy is being slowly cooled, a change occurs at 500 deg. C. whereby the beta breaks down, and the constituent known as the delta eutectoid, which is a definite compound of copper and tin ($SnCu_4$), is formed. The importance of this delta eutectoid will be seen later. Taking the case of an alloy containing 10 per cent. tin, solidification commences at about 1,000 deg. C., when a dendritic skeleton of alpha containing only about 2 per cent. tin is deposited. As the temperature falls the amount of tin contained in the alpha which is building up the structure, increases, as also does the concentration of tin in the still liquid portion, until at about 790 deg. C. the alpha formed holds 9 per cent. tin, and the whole solidifies. The period round about 790 deg. C. is favourable to the formation of the undesirable beta constituent, consequently the cooling through this range should be rapid if segregation is to be avoided. Cooling proceeds to 500 deg. C., and any beta which is present is split up, and delta eutectoid formed. It is obvious that with only 10 per cent. tin, only very small amounts of beta, and consequently delta eutectoid, should be formed under normal conditions. The above applies strictly to an alloy of 90 per cent. copper and 10 per cent. tin, but is approximately correct for Admiralty gunmetal.

Casting Temperature.

The casting temperature of Admiralty gunmetal has been thoroughly investigated. By itself, casting temperature is not everything, but in conjunction with good melting practice, will go far to ensure success. Although Admiralty gunmetal has a wide range of pouring temperature within which sound castings can be obtained, trouble is experienced if this range is exceeded in either direction. In a Paper presented to the Institute of Metals in 1918, Carpenter and Elam give the range of casting temperature as from 1,120 to 1,270 deg. C. It is interesting to place on record the fact that the casting temperature of Admiralty gunmetal, as applied to works' practice, was investigated by Messrs. Dance and Lillie as far back as 1911. The conclusions arrived at, which were not published at the time, coincide substantially with what is known as Admiralty gunmetal to-day. On this account, therefore, the following extracts from their conclusions are given:—

"The highest limit at which it is advisable to cast Admiralty gunmetal without fear of segregation taking place is fixed (after much practical experimental work) at about 1,220 deg. C.

"The bottom limit is decided by the temperature at which the metal melts, the speed of pouring, and the size and shape of the object. A casting having thin places in it, or sharp impressions, would naturally require a higher pouring temperature than would a thick solid casting. . . The bottom limit may be fixed at 1,100 deg. C. . . . . At this temperature it is possible to cast thick solid objects successfully. Therefore, between 1,100 and 1,220 deg. C. there is a range of 120 deg. C. in which all classes of Admiralty gunmetal may be poured without fear of low results through segregation, *provided that the metal has not been overheated previously.* (The italics are the present author's.). . . . 1,220 deg. C. is the highest temperature at which Admiralty gunmetal can be cast without fear of segregation; we have good results from metal taken to 1,250 deg. C., but the metal was not allowed to 'stew' in the fire; even in these cases segregation was present to a certain extent. It seems that the length of time the metal is allowed to stand at these high temperatures before pouring has a bad effect, not only by 'burning' the metal, but also by increasing the tendency to segregation of beta. . . ."

It is inadvisable in ordinary foundry practice to work with such an extended range as that given by Carpenter and Elam. It is suggested that a range of casting temperature from 1,120 deg. C. for thick sections to about 1,220 deg. C. for light

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work will probably be all that is necessary. A safe rule to follow is to consider the nature of the casting carefully, and cast at as low a temperature as possible within the range given above.

Equal in importance with correct casting temperature is the need for careful preparation and melting of the alloy. Practice varies in different foundries as to the exact method of making the alloy. Some melt the copper and bring it up to a high temperature, withdraw the crucible from the fire, add the tin and zinc, and cast; the idea presumably being to have as little loss as possible. This method is not considered good practice. Every foundryman knows the great rapidity with which pure copper takes up oxygen when molten. In the foregoing method the copper is melted and considerably superheated, to ensure that after the addition of the tin and zinc the casting temperature will not be too low. In addition, therefore, to a tendency to produce oxidised material, there is a possibility that the loss is actually greater with this method than where the additions are made to the crucible as soon as ever the copper is sufficiently molten. A good covering should be maintained, and the crucible withdrawn from the fire as soon as the correct casting temperature is reached. On no account should the material remain in the fire longer than is absolutely necessary.

"Liquation."

Neglect of the above precautions or carelessness on the part of the melter will certainly lead to trouble. In addition to actual unsoundness, the phenomenon known as "liquation" can be caused by improper melting. This trouble is more common with large castings, and is generally indicated by the appearance of a greyish white extrusion on the surface of the runner, or it may be seen welling up if the runner is knocked off too soon—this being known as "bleeding" in the

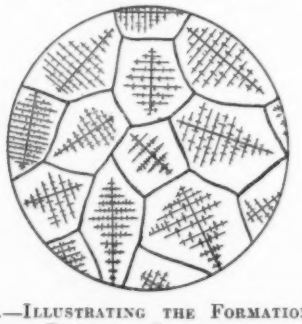

FIG. 4.—ILLUSTRATING THE FORMATION OF A DENDRITIC STRUCTURE.

foundry. Fractures of these castings will probably show what are known as "tin spots." The author is of the opinion that under circumstances which favour this form of trouble gunmetal will tend to "liquate" according to its degree of oxidation. In other words, the greater the state of oxidation the greater the tendency to "liquate." "Liquation," for instance, will occur in a casting where the section, casting temperature, and rate of cooling, etc., do not appear to justify it.

Those who deal with gunmetal will have noticed how "sluggish" or "pasty" it becomes when oxidised. It is thought that this falling off in fluidity, together with the possibility that the actual solubility of tin in copper is diminished when in this state, prevent the alpha solid solution from holding its full quota of 9 per cent. tin. This would have the effect of causing a greater accumulation of tin-rich liquid, which as solidification proceeded would be pushed about, and eventually trapped. In portions where there was very slow cooling quite big quantities of this tin-rich liquid would accumulate, and as the pressure of solidification came on some of it might even be squeezed through the wall of the casting. Some actual extruded material has shown from 22 to 25 per cent. tin on analysis.

It is a fact certainly that the poorer the quality of the gunmetal the less characteristic its structure becomes and the more delta eutectoid is found, indicating that the alpha solid solution has not taken up its proper share of tin in the initial stages of solidification.

The remedy for this form of trouble is primarily to ensure that the material is carefully made, and not overheated or left in the fire longer than necessary.

Secondly, the casting temperature should be as low as possible, in order that the mould may not absorb an undue amount of heat. Obviously the higher the casting temperature the more heat will be transferred to the mould and the longer it will take to cool through the danger range. In some cases special means may have to be taken to ensure sufficiently rapid cooling.

Structure.

It is generally possible to tell the quality of a piece of gunmetal by its fracture, and in this way it is really being judged on its structure. The actual examination of the structure under the microscope is very interesting, and it is often possible to determine the cause of trouble by this means.

By reason of it being a solid solution and having an extended freezing range (which, as indicated in the equilibrium diagram is from 1,000 deg. C. to 790 deg. C. approximately), gunmetal has what is known as a dendritic structure. The manner in which a dendritic structure is formed and an idea of its characteristic appearance will be seen by referring to Fig. 4.

In Fig. 5 is illustrated a typical photo-micrograph of good gunmetal, where the dendritic structure is very pronounced. This actual specimen was cut from a test-bar which gave 20.96 tons per sq. in. tensile, and 44 per cent. elongation. The other extreme is represented in Fig. 6, which is from a test-bar cast on a casting, and which gave only 10.0 tons per sq. in. and 5 per cent. elongation.

Examination under slightly higher powers reveals the delta eutectoid. This is a hard, brittle, bluish-white compound. Good gunmetal contains only very small amounts of this constituent, and then in very small pieces and evenly distributed. When a large amount of delta is present as in poor gunmetal it is usually found to be more or less in the form of a network, and it is the lines of weakness which are thus introduced which are the chief cause of low tensile and elongation. Figs. 7 and 8 show the relative amounts and distribution of the delta eutectoid in the strong and weak gunmetals in Figs. 5 and 6 respectively.

The specimens shown in Figs. 5 and 6 have been etched with an alcoholic solution of acid ferric chloride, which leaves the copper-rich portions almost unattacked, but considerably darkens the tin-rich portions. There is no sudden line of demarcation between the two, as the photographs may lead one to suppose, but a gradual merging of one into the other. An examination of a large number of bars, of which a comparison of Figs. 6 and 8 with Figs. 9 and 10 may be taken as being fairly typical, indicates that the physical properties of gun-metal are principally dependent on the structure.

The bar illustrated in Figs. 6 and 8 was cast on the casting, and, as previously stated, gave only 10 tons per sq. in. and 5 per cent. elongation. The bar shown in Figs. 9 and 10 was cast separately at the same time, and gave 15.44 tons per sq. in. with 21 per cent. elongation. The structures, and especially the relative amounts of the delta eutectoid in the three bars (21 tons, 15 tons, and 10 tons respectively) should be noted. The delta eutectoid has somewhat the same characteristic shape as the phosphorus in cast iron, and for much the same reasons. Fig. 11 illustrates a piece of this delta eutectoid at a higher magnification.

It may seem incredible that the change of beta to delta can occur in the solid material, and at as low a temperature as 500 deg. C., but this is nevertheless correct. The presence of much of this delta eutectoid may indicate that the casting temperature has been too high, and/or the rate of cooling too slow, or that the material has been oxidised through standing too long at a high temperature. In this latter case, evidence of oxidation will also be found. Whatever the cause, however, the result is the same, namely, weak gunmetal.

Heat Treatment.

As is to be expected, Admiralty gunmetal is amenable to heat-treatment. The correct annealing temperature undoubtedly appears to be round about 700 deg. C. Annealing at this temperature removes the "cast" dendritic structure, and gradually absorbs the delta eutectoid, giving finally a homogeneous solid solution of tin in copper, with improvement of the physical properties. For such castings as liners and bushes, etc., and, in fact, for all castings where sliding or rubbing contact is to take place, annealing would

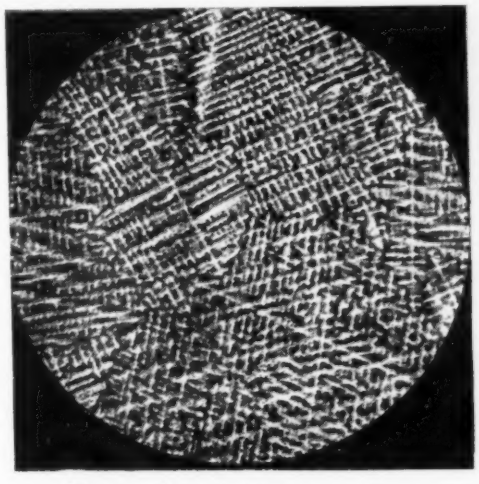

FIG. 5.—GOOD GUNMETAL. × 25.

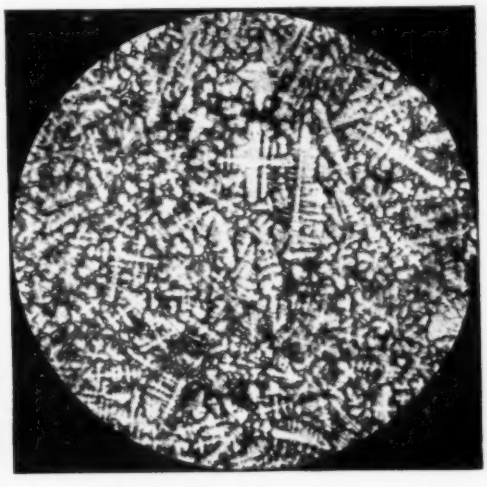

FIG. 6.—WEAK GUNMETAL. × 25.

be distinctly harmful, as the value of gunmetal as a bearing material is dependent on its "cast" structure, and particularly on its delta content. For this reason an alloy of 85 per cent. copper and 15 per cent. tin is even more suitable for a bearing metal, and is often used as such.

It is thought, however, that annealing would be an advantage with steam and hydraulic castings, etc., and although the author has had no experience of this as a regular works' practice, it is believed that it is carried out in some places. Experiences and opinions are invited as to the

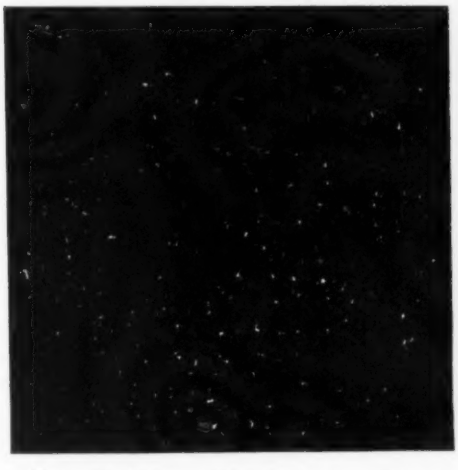

FIG. 7.—DELTA EUTECTOID IN GOOD GUNMETAL, SHOWN IN FIG. 5. × 50.

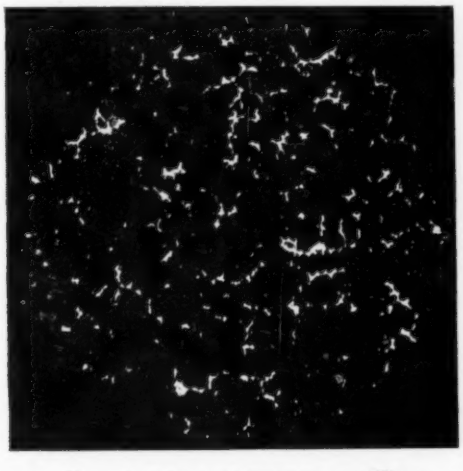

FIG. 8.—DELTA EUTECTOID IN WEAK GUNMETAL, SHOWN IN FIG. 6. × 50.

desirability or otherwise of annealing such castings as indicated.

Brasses.

Copper and zinc alloy in all proportions, but beyond 49 per cent. zinc the alloys cease to be of commercial value owing to extreme brittleness. The equilibrium diagram is interesting and worthy of study.

The line A—B—C in Fig. 12 represents the liquidus. The dotted line Ab Bc indicates the solidus, at which temperatures solidification is complete. Up to 37 per cent. zinc approximately, at atmospheric temperature, the structure consists of a solid solution of zinc in copper known as the alpha solid-solution. With alloys containing more than 37 per cent. zinc a second constituent known as the beta solid solution is found. Additions of zinc increase the amount of beta, until at about 46.5 per cent. zinc the structure consists of all beta. Further additions of zinc then cause the formation of a third constituent known as "gamma." The presence of gamma causes a considerable falling off in strength, making the alloys containing it useless. There is quite a large difference in physical properties between the alpha and beta constituents. The alpha, with its increased proportion of copper, being soft and ductile, whilst the beta, on the other hand, is harder and does not possess much ductility.

As regards ordinary cast brass, almost anything is used, and compositions are very variable.

The most remarkable feature of the alloys of copper and zinc, is the fact that the usual metals which are added, such as tin, lead, iron, manganese, aluminium, etc., are definitely soluble in the alloy also, up to certain amounts; and do not form third constituents unless added in excess of their limits of solubility. In other words, these metals have the same effect on the structure as additional zinc would have, but with the exception that the strength is increased, providing they are not added in excess of their solubility. The metals mentioned have different limits of solubility, and replace different amounts of zinc in the structure. For example, a brass containing 60 per cent. copper will hold up to 8 per cent. manganese without another constituent forming, and every per-cent of manganese so added, acts as an additional 0.5 per cent. zinc on the alpha-beta structure. Tin will dissolve up to slightly over 1 per cent., and will equal twice its amount in zinc. Lead is held in solution to the extent of 0.9 per cent., and has the

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same effect as an equal amount of zinc. The solubility of iron is slight, and is not known exactly, but in practice it is not advisable to add more than about 1 per cent. Aluminium has a very considerable influence, 1 per cent. of this metal being equivalent to 6 per cent. zinc. In these facts we have the explanation of what are known as the high-tensile brasses.

Manganese Brass.

A manganese brass of approximately the following composition will probably be familiar to many, and is greatly used, amongst other things, for the making of ships' propellers. Its composition is approximately 58.0 copper; 1.0 tin; 0.5 lead; 1.0 iron; 0.5 manganese; 0.4 aluminium; and 38.6 per cent. zinc, etc. An ordinary brass containing 38.6 per cent. zinc, would possess a structure of approximately 83 per cent. alpha area, and 17 per cent. beta area; but the manganese brass given above, would have a zinc value or zinc equivalent of 43.5 per cent., and this gives a very different structure, having only 31 per cent. alpha area and 69 per cent. beta area approximately. The tensile strength of this material when correctly made and cast, is in the neighbourhood of 34 to 35 tons per sq. in.

The structure of a sample of manganese brass of approximately this composition, is illustrated in Figs. 13 and 14. Fig. 13 shows the " blue etching

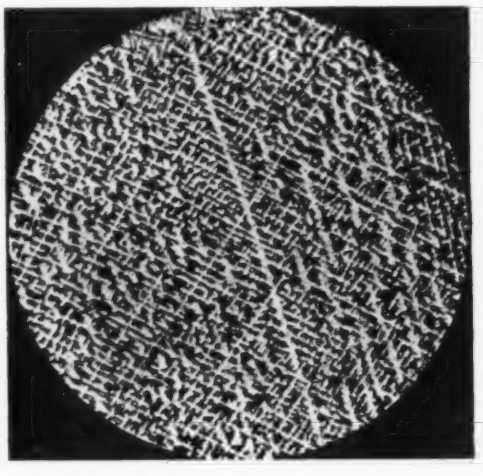

FIG. 9.—× 25.

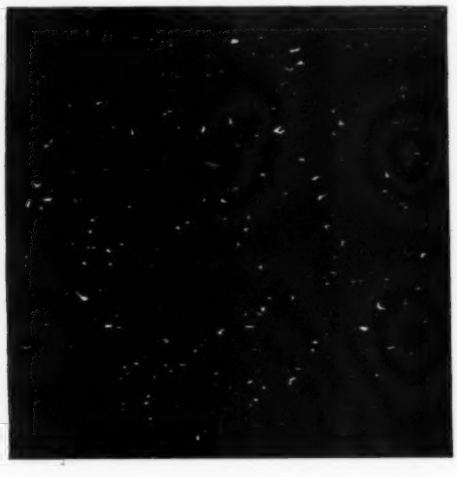

FIG. 10.—× 50.

FIG. 11.—DELTA EUTECTOID. × 500.

constituents," which are probably a solid solution of iron and copper, with possibly some tin, manganese or aluminium. These " blue etching constituents " should not be present in excess—which should not be the case, if the iron is kept to about 1 per cent. If present in excess, segregation will almost certainly occur. Fig. 14 shows the alpha-beta structure—the white areas being the alpha constituent. The actual amount of alpha in this specimen is approximately 30 per cent.

Casting Temperature.

The casting temperature of this material is very important, and as the range is very limited, the use of a pyrometer is essential. The range may be given as 1,000 deg. C., plus or minus 20 deg. C.

Owing to the physical properties of this material depending so much on the relative amounts of the alpha and beta constituents, the zinc content must be under control, if a consistent product is desired. This may be accomplished by either micro-examination, or by actual determination of the copper content in samples drawn at intervals, from the furnace, before tapping. Adjustment is then made if necessary.

The liquid contraction of this alloy is large, and necessitates special attention being given to " feeding." The method of casting a propeller blade is interesting, and is illustrated in Fig. 15. This is cast upright, and run from the tip. The pouring basin should be of ample capacity, and is kept closed with a plug until filled. When the plug is removed the pouring is regulated to keep the basin full. As the metal gradually rises into the flange, dirt is prevented from being trapped in the corners by means of rods. This can be done by observation, as the head is quite open. Pouring is continued until the level in the head reaches the height at the top of the runner. The runner then solidifies, and, at intervals, fresh hot metal is introduced into the open head, the metal in

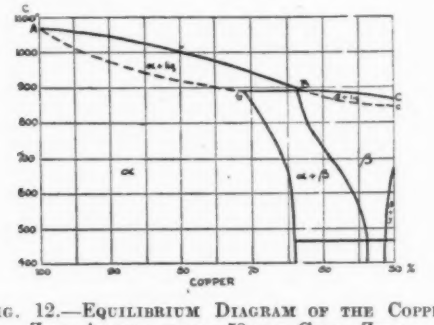

FIG. 12.—EQUILIBRIUM DIAGRAM OF THE COPPER-ZINC ALLOYS, UP TO 50 PER CENT. ZINC.

which is worked up and down with rods, and thus " fed." The size of head required is very nearly one-third of the weight of the casting.

Manganese brass has two marked characteristics. One is its remarkable fluidity and the other is its high surface-tension, due apparently to the instantaneous formation of an oxide film on the surface. For this latter reason, the filling of the mould must be continuous and the initial pouring done without splashing; consequently pouring basins with plugs are necessary.

White Metal.

The important bearings in marine engineering are lined with white-metal, usually of a tin base. Freedom from bearing trouble seems to depend

upon the continual maintenance of an oil film. Thus, in a bearing correctly adjusted and lubricated with suitable oil the metal surfaces should not actually come into contact, but should always be separated by a layer of oil.

The most perfectly machined surface has somewhat a resemblance to a ploughed field when seen under the microscope, even under low powers, so that the bearing material must necessarily be slightly plastic to enable small surface irregularities to be accommodated: also to allow for slight inaccuracy of fitting or alignment. On the other hand, it has been proved that hard bodies have smaller co-efficients of friction compared with softer bodies, and in the case of a bearing, wear longer. It is evident, therefore, that the perfect bearing material must possess two somewhat contradictory properties—on the one hand, that of being hard, to ensure low co-efficient of friction and long life; and, on the other hand, that of being soft and slightly plastic. Obviously, no single metal, or an alloy that is a homogeneous solid solution, can combine these two dissimilar properties, so that compositions are sought to produce structures where hard constituents are supported in a softer and slightly plastic matrix.

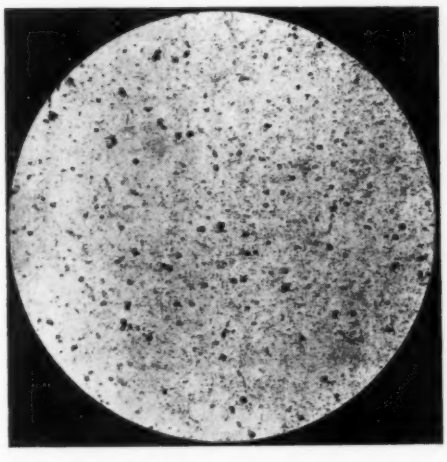

FIG. 13.—"BLUE ETCHING CONSTITUENTS." × 50.

How perfectly an alloy of 5 per cent. copper, 86 per cent. tin, and 9 per cent. antimony fulfils these conditions is shown in Fig. 16, which is a photo-micrograph of a specimen of this composition cut from an actual bearing. Two distinct compounds are present, the most striking being the almost perfect cubes of the tin-antimony compound. The other compound, which is that of copper and tin, not only serves the useful purpose of stiffening the almost pure tin matrix, but, being the first to solidify, and separating throughout the mass in the form of a dendritic network, prevents segregation of the tin-antimony cubes which are later formed.

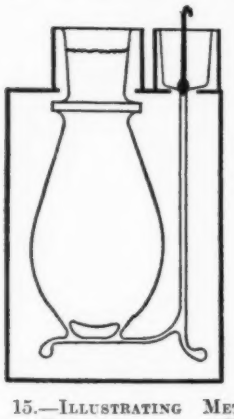

FIG. 15.—ILLUSTRATING METHOD OF POURING AND "FEEDING" PROPELLER BLADE.

It is desired to emphasise the importance of correct structure in connection with bearing metals, as the whole life of the bearing appears to depend upon it. It is therefore a matter of importance that the actual manufacture of the white-metal and the subsequent filling of the bearing be conducted with the necessary care and attention which it deserves. In many cases little thought is given to this side of foundry work (it is considered that the correct place for this work is in the foundry), and it says much for the amount of abuse which this material will stand that it does not give trouble more often.

First and foremost is the matter of temperature control. This is a comparatively simple matter with such a low melting-point alloy, yet it is often neglected. A suitably protected glass thermometer is all that is required, and should be in the hands of the man who has charge of this work. Preferably, the furnace itself should be fitted with a dial type of indicating thermometer. Melting should be carried out in some form of container where the atmosphere is excluded, or if this is not possible, special attention should be given to the surface covering.

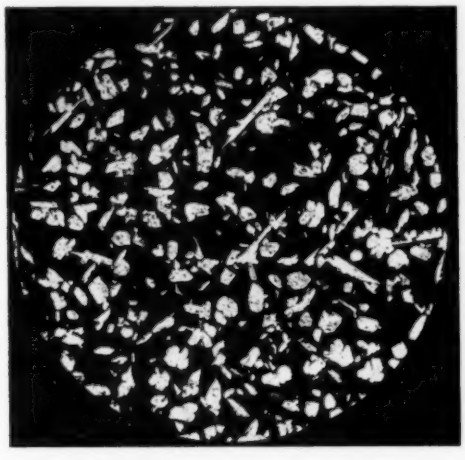

FIG. 14.—ALPHA-BETA STRUCTURE. × 50. APPROX. 30 PER CENT. ALPHA AREA.

A furnace that has been found satisfactory is shown in Fig. 17, which illustrates the actual pouring of a bearing. The furnace is gas-fired, and is fitted with an automatic regulator, by means of which the temperature can be kept round about a determined figure. It is also fitted with a "mixer," which consists of a perforated plate worked up and down in the liquid, by means of the outside handle. The rate of pouring is controlled by a handwheel, which regulates the opening of the outlet valve at the bottom of the container.

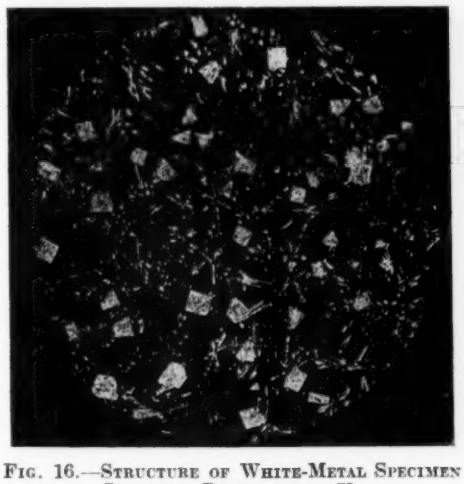

FIG. 16.—STRUCTURE OF WHITE-METAL SPECIMEN CUT FROM BEARING. × 50.

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Overheating, or standing for long periods without a protective covering, should be avoided at all costs.

It has been found necessary to obtain sound bearings, free of oxide inclusions, "sponginess," holes, etc., to run the whole bearing at one time from the bottom. For this purpose the casting to be lined should be evenly heated to about the melting point of tin, and tinned if possible. The

FIG. 17.—FILLING A BEARING.

bearing is fitted with a suitable size of "former," which is clamped on. Some of these are shown in Fig. 18. A stock of formers is gradually accumulated as new sizes come along, so that almost any size of bearing can be accommodated after a while.

The metal after skimming and "mixing" is run direct from the melting furnace, the bearings being filled from the bottom. The actual casting temperature should not be higher than necessary. With the particular composition given previously, the pouring temperature in use is about 420 deg. C.

The lower portion of the casting is cooled with an

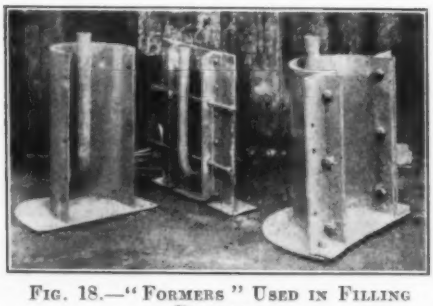


FIG. 18.—"FORMERS" USED IN FILLING BEARINGS.

air blast, whilst the top is just kept sufficiently hot with a blowpipe to keep the metal liquid and enable "feeding" to proceed.

Additional metal is added into the head from a small hand ladle, as required. This method has been found to give perfectly clean and sound bearings, which machine up without a mark.

The actual size of the tin-antimony cubes is believed to have an influence, and this method of filling gives an average size of approximately 0.0025 inch, which is considered satisfactory.

In conclusion, the author desires to express his thanks to Messrs. R. and W. Hawthorn, Leslie and Company, Limited, for their kind permission to publish this Paper.

THE LAWE SHIPYARD, South Shields, owned by Charles Reynoldson & Company, is being offered for sale by private treaty. The yard was established early in the war, and the firm specialised in coasting vessels of moderate size.

Visitors Attending the Conference.

As will be seen from the following list of those present at the Newcastle Conference, the various Branches of the Institute were well represented :—

F. Allan, Sunderland; J. W. Athey, Birmingham.

F. Bowden, Newcastle; A. E. Boddaert, Amsterdam, Holland; H. Bunting, Derby; Robt. Buchanan (past-president), Birmingham; William Bell, 336, Pollokshaws Road, Glasgow; Amos Brailsford, 18, Elswick Row, Newcastle; E. Bean, Hull; W. S. Betham, 9, Sth. Frederick Street, South Shields; A. A. C. Bimlop, 22, Ellison Place, Newcastle; Thomas Bell, Barrhead, Scotland; R. J. Blakey, Redcar.

F. J. Cree, Peterborough; F. M. Cramb, Bath; A. Campion, Glasgow; J. J. Cameron, Kirkintilloch; Pierre Chevenard, Impley (Nièvre), France; H. Cole-Estep, London; F. J. Cook (past-president), Birmingham; H. F. Clements, Jesmond; Col. W. F. Cheesewright, D.S.O., London.

John G. Dobson, Birmingham; D. Dalrymple, West Bromwich.

J. Ellis (past-president), London; Fred. G. Evans, Newcastle-on-Tyne; W. T. Evans, Derby; J. Ellis, London; Arnold Edwards, Cheltenham.

J. W. Frier, Wallsend-on-Tyne; H. Field, Birmingham; Ben Fender, Monkseaton; V. C. Faulkner, London.

E. T. Gardiner, Bishop Auckland; M. E. Gallon, Younger & Gallon; W. P. Gospel, Heaton, Newcastle; Colin Gresty, Wallsend.

Ben Hird, Cwmbran; A. Hodgson, Manchester; John R. Hyde, Sheffield; R. E. Hoy, Halifax and Hull; R. R. Hargraves, Manchester; W. G. Hollinworth, General Secretary, London; I. Housby, Ipswich; A. Hodgkinson, Manchester.

John Irvine, 14, Clarence Street, Paisley.

H. C. Jay, Newcastle; Lawrence Jackson, Sheffield; J. B. Johnson, Birmingham; Wm. Jolley, Manchester.

James Lee; G. Lillie, Newcastle; J. E. O. Little, Gosforth, Northumberland; J. Longden, Clydebank; A. H. Lewis, Bolton; Wesley Lambert, London; A. Logan, St. Peter's, Newcastle.

W. Mathews, Wallsend; Tom Makemson, Manchester; J. Mathieson, Consett; T. McFarlane, Horsehay, Shropshire; W. Marshall, Armadale; W. H. Moore, Birmingham; A. Marks, Dudley; R. A. Miles, Manchester; H. Musson, Birmingham; W. A. Macdonald, Sheffield; F. McGrah, Wolverhampton; J. Masters, Stalybridge.

L. Northcott, Halesowen; John W. Newton, Darlington; John D. Nicholson, 13, Taylor Street, South Shields.

J. G. Pearce, Birmingham; Chas. B. Pugh, Walsall; James M. Primrose, Falkirk; R. O. Patterson (senior vice-president), Blaydon-on-Tyne.

W. Rawlinson, Bolton; H. Robertson, Sunderland; H. L. Reason (past-president), Birmingham; Matt. Riddell (past-president), Glasgow; E. Jule Rang, Tynemouth; J. G. Robinson, Halifax; S. H. Russell, Leicester; F. O. Robinson, Widnes; H. James Roe, Birmingham; D. M. Robertson, Falkirk; F. Ryding, Wigan.

Daniel Smith, Palmer's, Hebburn; Oliver Stubbs (president), Manchester; John N. Simm, Monkseaton; R. W. Stubbs, Manchester; H. J. Simcox, Birmingham; S. E. Smith, Rowlands Gill; A. Sutcliffe, Todmorden; Arthur Sutcliffe, Bolton; J. E. Smith, Sunderland; Geo. Senior, Sheffield; J. Shaw, Sheffield.

D. R. Tullis, Glasgow.

J. P. Varma, London; R. Village, Sheffield.

Thos. Wilkinson, Stockton-on-Tees; D. H. Wood, Birmingham; R. C. Waddell, 2, Percy Street, Ibrox, Glasgow; H. Winterton, Glasgow; S. W. Wise, Newcastle.

James Young, Paisley.

THE WAGES regulated by the sliding scale under the Midland Iron and Steel Wages Board were advanced 2½ per cent. from Monday, June 9, to Saturday, August 2.

A PETITION for the compulsory liquidation of the Graiseley Engineering Company, Sydney Street, Wolverhampton, came before His Honour Judge Tebbs at the Wolverhampton County Court on June 2, but was dismissed.

AS A RESULT of negotiations between trade union leaders, acting for all the ironworkers not governed by the engineering trade conditions and awards at Staveley and Sheepbridge, Derbyshire, the wages of the whole of the workmen employed by the Staveley Coal and Iron Company, Limited, and the Sheepbridge Coal and Iron Company, Limited, have been advanced, except those in the engineering trades. The advance is of 3s. per week to day-workers, and 6d. per shift to shift and piece-workers.

(*Continued from page 476.*)

INCOME.

	£	s.	d.
Subscriptions Received	1,677	4	4
Sale of Proceedings, etc.	13	0	3
Interest on War Loan, Cash on Deposit, etc.	28	7	0
Miscellaneous Receipts	0	8	2
Balance—Excess of Expenditure over Income	239	3	4
	£1,958	3	1

BALANCE SHEET, DECEMBER 31st, 1923.

LIABILITIES.

				£	s.	d.
Subscriptions paid in advance				98	13	0
Sundry creditors				314	9	9
The Oliver Stubbs Medal Fund—						
£342 5 7 Local Loans £3 per cent.						
Stock at cost	£200	0	0			
Interest to date	15	0	4			
	215	0	4			
Less : Cost of Medal, 1923	10	0	0	205	0	4
Surplus at December 31st, 1922	965	7	3			
Less : Transferred to Oliver Stubbs Medal Fund 3 17 0						
Excess of Expenditure over Income for the year ended 31st December, 1923 239 3 4	243	0	4			
				722	6	11
				£1,340	10	0

ASSETS.

	£	s.	d.	£	s.	d.
CASH IN HANDS OF SECRETARIES—						
Lancashire	12	8	3			
Birmingham	39	11	4			
Scottish	19	0	9			
Sheffield	50	3	3			
London	14	12	3			
East Midlands	20	5	4			
West Riding of Yorkshire	9	14	1			
Coventry	5	18	4			
				171	13	7
Lloyds Bank, Limited—						
General Account	121	9	1			
Deposit Account	300	0	0	421	9	1
The Oliver Stubbs Medal Fund—						
£342 5 7 Local Loans £3 per cent. Stock at cost	200	0	0			
Balance in hand Lloyds Bank, Ltd.	5	0	4	205	0	4
Investment Account—						
£100 5% National War Bonds						
£350 5% War Loan at Cost				432	10	1
Furniture, Fittings, and Fixtures—						
Per last Account	66	7	8			
Less : Depreciation 10% ..	6	12	9			
	59	14	11			
Additions Typewriter and Seal	35	2	0	94	16	11
Birmingham Branch—						
Special Advance				15	0	0
				£1,340	10	0

We have prepared and audited the above Balance Sheet with the Books and Vouchers of the Institute and certify same to be in accordance therewith.

J. & A. W. SULLY & CO.,
Chartered Accountants,
April 15th, 1924. *AUDITORS.*

The report was adopted.

THE PRESIDENT then proposed the adoption of the balance-sheet for the Session. The Finance Committee and the General Council, he said, had been through it very carefully, and were satisfied that it was a correct one.

No questions were asked, and the balance-sheet was adopted.

The New President.

THE PRESIDENT proposed the election of Mr. R. O. Patterson (Senior Vice-President) as President for the Session 1924-25. In Mr. Patterson the Institute had—or would have, he hoped—a President who would be able to take them along on the right track. He had a wide experience of all sides of the foundry industry, and had travelled considerably in this country and abroad. He (Mr. Stubbs) felt fortunate to be able to put before the members the name of Mr. Patterson, and to assure Mr. Patterson of their loyal support during his term of office. One could not wish for a finer body of members than those of the Institute. They had all worked together splendidly, and one was very much better for having moved among them.

MR. F. J. COOK, in seconding the proposition, endorsed all that Mr. Stubbs had said about Mr. Patterson. Those who knew him intimately knew that he had only one fault, and that was his great modesty. That, however, would not interfere with his carrying out the duties of his high office, and they would all be very proud to have him in the chair.

Mr. Patterson was unanimously elected.

Photo [*Elliott & Fry*
MR. V. C. FAULKNER (Junior Vice-President).

Mr. V. C. Faulkner was trained under Professor J. O. Arnold at Sheffield University. He was a pioneer of the electric arc furnace, and has travelled extensively in Western Europe in this connection. Some three-and-a-half years ago he was appointed Editor of the "Foundry Trade Journal." He joined the Institute in 1908, and has read several Papers on electric steel manufacture. In 1921 he was appointed secretary of the London Branch, and was elected President in 1923, an office he still holds.

MR. STUBBS then invested Mr. Patterson with the chain of office, and trusted he would be given health and strength to wear it, and that they would all be better men at the end of his term of office.

MR. PATTERSON, who was received with loud applause, expressed his great appreciation of the honour done him. He was just beginning to realise, he said, the magnitude of the office, but he hoped that, with the help of Mr. Stubbs, the Council and the members, the Institute would have another successful year.

THE PRESIDENT, referring to the election of Vice-Presidents, expressed regret that Mr. E. H. Broughall had had to withdraw from the position of Senior Vice-President (to which he would have succeeded this year), owing to continual ill-health. The Council therefore had asked Mr. J. Cameron, of Glasgow, to fill that office. Mr. Cameron, in his usual good-natured way, had stepped into the breach, and he (the President) was sure that that would meet with the entire approval of the members, and he proposed that Mr. Cameron be elected Senior Vice-President for the ensuing year.

MR. JOHN SHAW seconded Mr. Cameron's nomination, and said he had known him for some years, and, as a member of the Test-Bar Committee, Mr. Cameron was most assiduous in his duties. At his own works he had made about 150 tests, and had carried them out to completion, and that would give them some idea of what to expect during Mr. Cameron's term of office.

Mr. Cameron was unanimously elected.

MR. CAMERON, in returning thanks, said how much he had always enjoyed and appreciated the membership of the Institute. After expressing his regret that Mr. Broughall was unable to carry on,

he said he felt his own limitations in succeeding such a number of excellent Presidents; however, he would try to do his best.

MR. T. MAKEMSON then proposed that Mr. V. C. Faulkner, President of the London Branch, be elected Junior Vice-President. Mr. Faulkner's work, he said, was well known, and he had been a member for quite a long time. His work as a practical metallurgist was also well known to all.

MR. L. NORTHCOTT, M.Sc. (Birmingham).

Mr. L. Northcott, of Halesowen, has been studying at the University of Birmingham since the war, and has carried out considerable research work on cast iron, which he is continuing for the Ph.D. degree in Metallurgy. His first Paper, on "Temper Carbon," was presented to the Iron and Steel Institute in May, 1923. At present he is investigating the effects of nickel upon malleable cast iron.

He had had a most varied experience as a metallurgist and foundryman, both in this country and on the Continent, and was a recognised authority in certain branches of steel works' practice. He had just completed a very successful year of office as President of the Branch; he was responsible probably more than any other man for the success, from the British point of view, of the International Conference in Paris last year.

MR. FIELD (Birmingham), in seconding, said it had always been the desire of the officers and Council of the Institute to nominate for this high office a gentleman in whom they had confidence. In putting Mr. Faulkner's name forward, the Council felt that they were fulfilling the conditions which had always been fulfilled before, and he (the speaker) felt that he was only voicing the opinion of the Council when he said that Mr. Faulkner would fill the office with every grace and with every ability.

Mr. Faulkner was unanimously elected.

MR. FAULKNER, in expressing his thanks, said he was deeply conscious of the honour which had been done him. He did not take it so much as a personal honour, but as a recognition of the important character of the work which had recently been carried out by the London Branch. Also, perhaps, it was some recognition of the use of technical journalism to technical societies; when the time came for him to assume the chain of office of the Institute he promised that he would do his best to keep up the traditions of the Institute.

Hon. Treasurer and General Secretary.

MR. OLIVER STUBBS then proposed that Mr. F. W. Finch be re-elected Hon. Treasurer. Mr. Finch was, he believed, the first one to suggest the formation of the Institute of British Foundrymen, and, although he was not able to attend meetings very often, his interest was just as great as ever.

MR. H. L. REASON seconded, and Mr. Finch was unanimously re-elected.

THE PRESIDENT proposed the re-election of Mr. W. G. Hollinworth as Secretary.

This was seconded, and Mr. Hollinworth was unanimously re-elected.

MR. HOLLINWORTH expressed thanks for his re-election, and assured the members that he would continue to do his best for the Institute.

Members of General Council.

A ballot was taken for the election of five members of Council to fill the vacancies on the Council. The members ultimately elected were Mr. A. R. Bartlett (London), Mr. Wesley Lambert (London), Mr. H. Pemberton (E. Midlands), Mr. J. E. Roberts (Coventry), and Mr. J. Shaw (Sheffield).

Trustees.

THE PRESIDENT proposed the re-election of Messrs. R. Buchanan, F. J. Cook, and Mr. Oliver Stubbs as Trustees of the Institute. This was seconded, and carried unanimously.

Auditors.

On the motion of the PRESIDENT, seconded by MR. STUBBS, Messrs. J. and A. W. Sully & Company, chartered accountants, were re-elected Auditors.

MR. H. L. REASON moved that the Secretary be instructed to write to Mr. Broughall expressing sympathy in his illness, and regret that he was unable to carry on as Vice-President. He thought Mr. Broughall would very much appreciate a message from the full Convention. He was almost one of the founders of the Institute, had done yeoman service, and had been looking forward with a good deal of pleasure to occupying the chair as President, and it was only through ill-health that he had had to give up the idea. His illness was very serious.

THE PRESIDENT said that that would be done, and he felt sure all of the members felt very much Mr. Broughall's inability to carry on.

Greetings from the United States.

A telegram from MR. G. H. CLAMER was then read as follows:—

MR. A. LOGAN.

Mr. A. Logan presented the Paper on "Non-Ferrous Alloys in Marine Engineering" at the Newcastle Conference. Prior to his appointment in December, 1917, as chief chemist of Messrs. R. & W. Hawthorn, Leslie & Company, Limited, he was five years with Mr. H. J. Young in the laboratory of the North-Eastern Marine Engineering Company, Limited. He became a member of the Institute of British Foundrymen in 1918, and is also a member of the Iron and Steel Institute, the Institute of Metals, and the Royal Photographic Society.

R. O. Patterson, Blaydon-on-Tyne.

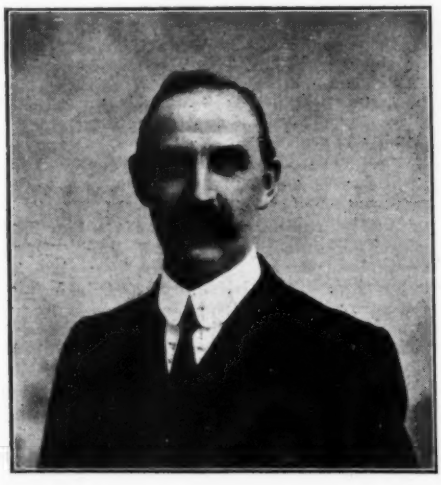
On behalf American Foundrymen's Association I extend to you personally and to the Institute of British Foundrymen greetings and best wishes for a successful Convention. Kind invitation received; regret cannot be with you.—G. H. CLAMER.

THE PRESIDENT proposed that a suitable reply be sent to Mr. Clamer, which was agreed to.

Mr Stubbs Elected Honorary Member.

THE PRESIDENT then mentioned a matter which had been dealt with at the Council meeting on the previous evening, that some slight recognition should be made of the extraordinary services rendered to the Institute by the Past-President,

Mr. Stubbs. Mr. Stubbs had stepped into the breach last year, thereby doing both the Institute generally and the Newcastle Branch in particular a very good turn indeed. The Newcastle Branch was not quite ready to carry on, but Mr. Stubbs stepped into the breach and had filled it admirably. Therefore he proposed that Mr. Stubbs should be made a honorary life member of the Institute. It was the highest honour that it was in their power to give, and he believed it would be agreed it was the least they could do.



MR. JOHN SHAW (Oliver Stubbs Medallist).

Mr. J. Shaw was educated at the Farnworth Grammar School, and continued studies at the evening classes at the Widnes Technical School and at Liverpool University where he studied engineering under Professor Hele-Shaw. Later in life he took the full metallurgical course at the Staffordshire County College under the late Mr. Walter Macfarlane. Mr. Shaw served his time with the Widnes Foundry Company, being appointed assistant foreman at the age of 19, and full foreman at 22. After taking charge of a small foundry in North Wales, he was appointed foundry manager to Messrs. Cochran's, of Dudley, and, by courtesy of this firm, he was loaned to the Ministry of Munitions as Director of Grey-iron Castings. After the war he joined his present firm, Messrs. The Brightside Foundry and Engineering Company, as manager of their largest works. Mr. Shaw joined the Institute of British Foundrymen in 1906, and has been a member of the General Council for over ten years. He is also a member of the Literary, Awards and Finance Committees. He is at present chairman of the Test Bar Committee, and was Branch-President of the Birmingham Branch for two years in succession (1915-16-17), and President of the Sheffield Branch in 1923.

MR. G. E. ROBERTS, who seconded, endorsed what the President had said. It was common knowledge that Mr. Stubbs had devoted an unprecedented amount of time to fulfilling the high office to which he had been called. He believed Mr. Stubbs had been round to almost every Branch during his period of office. He had given counsel to everyone who had asked for it, and added dignity to the office of representing the Institute at various conferences to which the Institute had been called to send representatives, and he (Mr. Roberts) was certain that the Institute would really be doing the right thing in recognising Mr. Oliver Stubbs' services in the manner suggested.

MR. JAMES SMITH, President of the Newcastle Branch, supported the resolution. He said he had known Mr. Stubbs for a considerable time, and he was delighted to think that at Newcastle they were making him a honorary member of the Institute. It was eighteen years ago since the Institute had held its last Convention in Newcastle, when their dear and respected friend, Mr. Cook, was made President, and he was sure it would be a great pleasure to the Newcastle Branch to know that they had conferred honour upon their old friend, Mr. Stubbs.

The resolution was carried unanimously.

MR. OLIVER STUBBS, in a brief acknowledgment, said how much he appreciated the honour, which he would never forget and would always respect.

PRESIDENTIAL ADDRESS.

The President then delivered his presidential address.

GENTLEMEN,—

It gives me great pleasure to welcome you to the banks of coaly Tyne.

The last Conference held in Newcastle dates back to the very early days of the Institute, and great strides have been made since that day. Great as the progress has been, however, there is an immense field in front of us which requires our attention at the earliest possible moment.

The years which have passed since the close of the great war have, with one or two exceptions, been exceptionally difficult for the general foundry trade of the country. The post-war unrest, expressing itself in strikes and restrictions of output, has been one of the main factors in the destruction of our trade. The position to-day, whilst still most uncertain, is no doubt considerably better, and I am glad to say that prospects at the moment are more cheering, but the natural volume of trade is still very short. How can we as an Institute help matters along? What is firstly required to my mind is that the selling price of castings be materially lowered. This can only be done to-day by either lower wages or increased output. The first, I think we are all agreed, is out of the question; in fact, most of us will say that wages to-day are too low, and we would much rather like to see a rise, were such a thing economically possible.

The second method is one that takes some thinking over, and can only be approached from the view of giving better facilities in our foundries so that men can give greater output with less or certainly no more effort.

Great progress has been made in several directions, and it behoves us to study all new processes and, wherever possible, apply them in our own plants. There are a few developments which I should like to mention here as being worthy of our consideration.

Centrifugal Castings.

Take the question of centrifugal castings. This operation has been extensively developed, particularly in certain pipe foundries, and would appear to be making great headway, making stronger and lighter pipes than is possible by the old methods, and thereby lowering the cost to the consumer. Developments are also proceeding with centrifugal castings for engineering purposes. There are great possibilities in this direction, for if we can turn out a lighter and stronger casting so much the better for the engineer.

MR. C. W. H. HOLMES, M.Met. (Birtley).

Mr. C. W. H. Holmes, M.Met. (Birtley), of Lamesley, near Gateshead, was a pupil under the late Mr. H. Pilkington, M.I.C.E., M.I.M.E. (Past President of the I.B.F.), at Sheepbridge Iron Works. Afterwards he became assistant analyst to the Admiralty, and subsequently metallurgist to the Director of Inspection of Steel (Land Service), and foundry manager to the Birtley Iron Company, with which firm he has now been associated for five years. He is a Master of Metallurgy in the University of Sheffield Carnegie Research Scholar, Member of the Iron and Steel Institute, and Member of the British Cast Iron Research Association. His publications include: "An Investigation on the Factors Influencing Grain and Bond in Moulding Sands," J.I.S.I., 1922, Volume II.; "Moulding Sands," read before the Newcastle Branch of the I.B.F., 1923; "The Testing of Moulding Sands, with Special Reference to Standardisation," read before the Paris Congress, 1923; "The Testing of Moulding Sands," read before the Society of Chemical Industry, 1924.

Melting Iron and Riddling Sand.

Then there are foundrymen at work experimenting with oil-fired furnaces in order to cut out the cupola, with a view of improving the quality of their molten metal, to suit high-class castings such as motor cylinders, which particularly require an iron low in total carbon.

Wonderful progress has been made, I am led to understand, by certain Midland aluminium firms in the production of die-castings. Castings as large as six-cylinder crank-cases are successfully made in dies, which surely must constitute a

Monsieur P. Chevenard.

Monsieur Chevenard was trained at the St. Etienne School of Mines, where he obtained first-class honours. He became attached to the Imphy Works of the Commentry Fourchambault and Decazeville Steel Company. In 1919 he was elected to the Chair of Metallurgy at the St. Etienne School of Mines whilst still retaining the position of head of the Research Department at the Imphy Steel Works. His studies on the dilatometric analysis of alloys have received universal acknowledgment.

record. Then, again, what about our cupolas? Do we make enough of our engineering knowledge and apply same to save handling of material? I have attempted recently, in a small way, more or less mechanically to charge a pair of cupolas, and whilst not for a moment holding this arrangement out to be a perfect one, great savings have been made. My trouble was, however, that the whole installation had to be made in our own works. The only help received was from the illustrations in the technical press. Now in this direction is there not an opening in this country for a good foundry engineer? One who could act as a consultant, such as our American friends have in plenty. I visited the United States in 1919, and amongst many other things I was greatly taken by the gyratory riddles seen there in nearly every foundry. On my return I bought three of these, and can safely say that my expenses for the trip were more than made out of these riddles inside of 12 months. They are one of the greatest money-savers in a foundry, and yet the local agent tells me that he has the greatest difficulty in selling any of them up here on the North-East Coast. Now this should not be. We must wake up and take advantage of every mechanical appliance we can lay hold of.

The Sand Question.

The sand question is also one worthy of consideration. I am not satisfied that we get the fullest possible life out of our sands, but research is being made in this direction and should bear valuable fruit in time. The handling and preparation of sand is one that presents many interesting points to the foundryman, and large economies should be made by a proper application of good engineering practice in this connection.

The test-bar question has been very thoroughly ventilated during the past twelve months, and has proved to be a bigger proposition than was generally thought at the beginning. A vast amount of work has been done by the international committees, but nothing definite has been settled, and it would appear that a lot of ground has to be covered before finality is reached. I should imagine that perhaps this is a question which must be approached scientifically and without any regard to individual preferences.

Classification of Pig-Iron.

Has the time not arrived to make a move in the direction of the classification of pig-iron by analysis? This is a most important question and is long overdue. I know that certain pig-iron makers have the greatest reluctance to do anything in this matter; on the other hand, there are others who seem to want to do their best to help along the movement. The best way in which we can help is to encourage those who act sympathetically in the movement and buy our pig-iron from them whenever possible. With all the metallurgical knowledge we have at our disposal in these days, it seems ridiculous to have to buy our pig-iron by fracture alone, and I am quite sure that if each one of us moves persistently in this direction the producers will come into line in due time. The same remarks apply equally to our coke supplies. These for a very long time have been anything but satisfactory, and I am sure that we are now quite strong enough to insist upon our requirements being filled.

With regard to these last two items of pig-iron and coke, we might, I think, take a leaf out of the book of our American cousins, who have got both questions settled on very commonsense lines.

Co-operative Research.

Now to help us along these sort of lines we have our own Institute, the British Cast Iron Research Association, and our various trade associations. These, whilst working on independent lines for the common good, ought, I think, to be brought into closer fusion. The Institute for the individual, the other two for the firms.

Mr. Colin Gresty.

Mr. Colin Gresty, the honorary secretary of the Newcastle Convention Reception Committee. Mr. Gresty is chief assistant in the laboratories of the North Eastern Marine Engineering Company, Limited. He has contributed Papers on the "Microscopy of Cast Iron."

We all know what the Institute has done—and still does—for each of us, but are we making the best use of the research association?

After a vast amount of work this association has issued from its teething stage and is now in full swing and doing valuable work for the industry. It provides expert technical advice, and reports on any difficulty or trouble experienced by its members in their everyday practice.

The reports provided cover a very wide range, including pig-iron, sands, fuels, moulding practice, cupola practice, designing of castings, production of semi-steel, malleable castings, and the mixtures and methods required for special irons for various purposes.

An excellent library is at the disposal of the members, and the Quarterly Bulletin provides a

means of communication between the Association and the members on matters of common interest, and contain abstracts of literature relating to cast iron and foundry practice.

The Association conducts investigations for the purpose of learning more about the production, treatment, and the use of cast iron and malleable iron, and so enables members to improve their melting and moulding practice. The investigations are carried out at the most important laboratories in the country and in the works of members.

Periodical reports are issued as and when investigations are complete, and these appeal both to the ironfounders and to the engineer whose foundry is only part of his business.

The Association is working for the progressive standardisation of materials and methods of testing in the industry, acceptable to foundrymen. It aids members to meet specifications issued by various consumers and lends assistance in modifying specifications based upon inadequate metallurgical knowledge of foundry products.

These few words, whilst briefly indicating the activities of the Association, do not by any means cover the full field. It is an indispensable acquisition to the foundry trade, and I am looking forward to great strides being made in our business through the efforts which are being made.

Now with regard to our commercial associations, I think a field which might be profitably invaded is one which might be called commercial research. By this I mean that propaganda work should be instituted so that the consumption of castings might greatly be increased. For example, American railway trucks have cast-iron wheels; South African telegraph poles have cast-iron bases. Here we have "imported" wood poles, probably costing as much as steel and cast-iron poles.

In America and other countries they have cast-steel automatic truck couplers. A few cases of this sort instituted in this country would enormously increase the output of castings and thereby decrease our costs.

Shortage of Skilled Moulders.

We now come to another question which is causing a serious position in our industry, that is the shortage of really skilled moulders. Moulding is perhaps without exception the most skilled of all the engineering branches. I think that a moulder, and perhaps a blacksmith, is born and not made, and if statistics were taken out I am sure that a big percentage of boys apprenticed to the trade fail to become highly skilled men. Unfortunately moulding is a dirty trade, and it is difficult to get the best class of boy to take it up. It is therefore up to the employers to make conditions more attractive. Could we but get the boys interested in the metallurgical side of cast iron, even to a very elementary degree, I am sure that their interest in their work would be multiplied many times. It would, therefore, seem desirable that each works or a group of works should institute some sort of training class for apprentices. The most important, and by far the most interesting, subject for such boys to study would be that of cupola practice. The woeful ignorance of this subject shown by the average foundry operative is really terrible, although when one looks back to the days before the Institute of British Foundrymen the ignorance of the bulk of the employers on this same subject was equally abysmal. Therefore let us get at it, get hold of the boys, and train them up in the way they should go.

In conclusion, Gentlemen, may I sincerely thank you for having elected me your President. I am fully aware of the responsibility of the position, and of the difficult task it is to fill the chair, particularly when following such an outstanding personality as Mr. Stubbs, who has done so much towards bringing the Institute up to its present state. I know that I have his help at my disposal during the coming year, which I trust will carry with it the same success as last year.

Newcastle Illustrated Chronicle.

SOME OF THE DELEGATES ATTENDING THE NEWCASTLE CONFERENCE.

Vote of Thanks to the President.

MR. F. J. COOK proposed that a vote of thanks be accorded to the President for his very interesting and thoughtful address. He believed that what the President had said would show that the Institute had the right man in the right place.

MR. OLIVER STUBBS, who seconded, drew attention to the excellent work which had been done by Mr. Patterson, and expressed the opinion that in him the Institute had an excellent President. He had given them a great deal to think about in the course of his address. Referring to Mr. Buchanan's remarks, he agreed that it was time the junior members came along and did some of the work, and he wanted to get junior members interested in the work as much as possible. The older ones could not go on for ever.

The vote of thanks was carried unanimously.

The President briefly acknowledged it.

Vote of Thanks to Retiring Officers.

MR. RUSSELL proposed a vote of thanks to the retiring officers for the work they had done, mentioning particularly Mr. Stubbs and Mr. Broughall.

MR. COLE-ESTEP seconded, and emphasised the work of the Test-Bar and Rules Committees.

The vote was acknowledged by Mr. R. Buchanan.

XUM

Book Review.

Lehrbuch der Eisenhüettenkunde. By Bernhard Osann. Vol. I. — Leipzig: Wilhelm Engelmann, Mittelstrasse, 2. (Price 29 gold marks, sewn; 32 gold marks, bound.)

The first edition of Professor Osann's treatise dealing with pig-iron production was published in 1915, but has been out of print for over three years, the author being fully occupied with his lectures at the State mining academy at Clausthal, getting ready for the press editions of his book on iron and steel foundry practice, the second volume of the present treatise on iron and steelworks practice, besides thoroughly revising the text of the first volume for the present second edition. One of the sections, that on cokeries, is quite new; those on heat-saving and blast-furnace gas management have been specially revised and the number of numerical examples increased. In the section dealing with hot-blast stoves a brief outline is given of methods of measurement. Some account is also given of the ways and means which had to be resorted to during the war owing to the shortage of raw materials. As during and since the war a considerable change has taken place in the sources of supplies of iron ores, the composition of the burden for the blast furnace has received special consideration. Upon the whole, the number of pages of the book have been increased by about a third of the first edition to over 920, including tables, appendices and index, and the number of illustrations has also been raised in about the same proportion. Some obsolete processes, appliances and other matter could, however, have been omitted and the size of the book kept down.

Professor Osann is one of the leading German writers on the metallurgy of iron and steel, and his books have been aptly described as encyclopædias of the knowledge of the subjects dealt with. He is also known as a bold controversialist in the German periodical technical literature. Judging by his numerous references, however, he seems to have only second-hand knowledge of matters published in non-German literature, and hence some of the information given is not strictly up to date. Picking out at random one example, he condemns as a mistaken notion the Prudhomme process of using wood as fuel in the blast furnace as actually tried in Chile. Why—he asks—carry on wood distillation in the blast furnace and not in a separate plant? This, of course, is the time-honoured way; but we believe Prudhomme (the name of the inventor of the process, and not the geographical name) has tried both ways, and has preferred his own. The experimental blast furnace was standing idle, may be, in 1912, but it was to be restarted quite recently. Apart from such small blemishes, however, Professor Osann's book will be a useful guide to the science and practice of pig-iron manufacture in Germany.

Trade Talk.

MR. DUDLEY DOCKER, iron and steel merchant, of Exchange Buildings, Birmingham, has relinquished his business owing to ill-health.

THE BRISTOL OFFICE of the British Reinforced Concrete Engineering Company, Limited, is now at Sun Buildings, Clare Street, Bristol.

A. LAKIN & SON, Totley Rise, Sheffield, have been appointed sole agents for Yorkshire, Derbyshire and Lincolnshire for the Lancashire Metal Flux Company, of Heywood.

A FIRE BROKE OUT recently at the premises of Messrs. Hodgetts, brassfounders, Helm Works, Bordesley Green, Birmingham. Five engines were engaged, and the damage is stated to be severe.

THE BLYTHSWOOD SHIPBUILDING COMPANY, LIMITED, Scotstoun, have obtained orders for two exceptionally large oil-carrying vessels, one from Christiania owners and the other from Haugesund. The vessels will each be 500 ft. in length and of 13,000 tons deadweight. They will be propelled by twin-screw Burmeister & Wain-Harland & Wolff Diesel engines, supplied by John G. Kincaird & Company, Limited, Greenock.

THE OUTPUT OF shipbuilding from Sunderland yards during May was five vessels, with an aggregate gross tonnage of 21,659, making a total for the five months of the year of 26 vessels and 93,935 gross tons. This is an advance on last year, when for the corresponding period the output was seven vessels and 19,402 gross tons, and for the first five months of the previous year, when it was 11 vessels and 48,149 gross tons.

A COMPLAINT OF high prices in the electrical industry was made at Birmingham City Council last week by Mr. Beale, chairman of the Electric Supply Committee. Four firms, he said, were asked to tender for new electric plant, and prices ranged from £9,000 to £9,765. These were so great an advance on prices at which similar plant already on order was being obtained, that it was obvious, he maintained, the four firms were controlled by an Association. The contractors supplying the plant on order agreed to accept the new work as an extra for £3,615, which the Committee assumed gave a fair return to the manufacturers.

MR. B. A. DANIEL, of 26, Great St. Helens, London, E.C.3, has been appointed representative for semi-finished products and for bars, joists, plates, etc.; and C. M. Hill & Company, Coventry House, South Place, E.C.2, have been appointed agents for rails and other railway materials for Soc. An. des Forges de la Providence, of Marchienne-au-Pont, Belgium.

THE WALES AND MONMOUTH BRANCH of the Institute of Mechanical Engineers held their first summer outing and meeting on Friday, May 30. The Mayor of Swansea invited the members to lunch at the Hotel Metropole, after which the party was taken for a charabanc drive into the Gower district, which was very much appreciated by all who took part. The South Wales and Monmouth Branch of the Institute of British Foundrymen was represented by their first Vice-President, Mr. F. Taylor, J.P., and the Hon. Secretary, Mr. J. J. McClelland. The President of the Institute of Mechanical Engineers was also present. During the luncheon the Mayor proposed the toast of "The I.Mech.E.," which was responded to by Mr. W. Patchell. Mr. Roberts, the immediate Past-President of the South Wales and Monmouth Branch, proposed the toast of "South Wales and Swansea" in a very humorous speech, which was responded to by Ald. Ivor Gwynne, Chairman of Education Committee. Mr. Crouch (President, Chamber of Commerce), Col. Sinclair (Chairman, Electricity Committee), and Mr. Burr (Chief Electrical Engineer) added to the response.

Contracts Open.

Aberdeen, June 16.—One mile of 12-in. and 10-in. diameter cast iron pipes and specials, for the Town Council. Mr. G. Mitchell, 41½, Union Street, Aberdeen. (Fee, £2, returnable.)

Dunfermline, June 19.—For supplying and laying about two miles of cast-iron pipes, 15-in. diameter, together with sluice valves, etc., for the Dunfermline Corporation. Crouch & Hogg, chartered civil engineers, 7, Lynedoch Street, Glasgow. (Fee, £2 2s., returnable.)

Kendal, June 13-27.—Water supply works for the South Westmorland R.D.C., including supply of 686 tons of 6-in., 5-in., 4-in., and 3-in. cast-iron spigot and socket pipes, etc. Taylor & Wallin, Commercial Union Buildings, 47, Pilgrim Street, Newcastle-on-Tyne. (Fee, £5, returnable.)

Mexborough, June 21.—3-in., 4-in., and 6-in. cast-iron spigot and socket water pipes, for the U.D.C. Mr. J. B. Feltham, waterworks engineer and manager, Station Road, Mexborough. (Fee, 10s. 6d., returnable.)

Personal.

MR. GEORGE HATTON, managing director of the Round Oak Iron and Steel Works, has been elected chairman of the Midland Iron and Steel Wages Board in succession to the late Mr. George Macpherson, who held the position for many years.

Wills.

PRIEST, T., of Benjamin Priest & Son, chain, nail and rivet manufacturers, Old Hill, Staffordshire £13,244

MORRIS, A. C., joint managing director, Heaton & Dugard, Limited, wire manufacturers, Birmingham £8,530

HUTTON, A. W., lately managing director of John Russell & Company, Limited, and of the Britannia Iron and Steel Company, (Bilston), Limited £6,155

Obituary.

MR. R. W. RUCKER, senior partner in Henry Rogers, Sons & Co., died recently. The business will be carried on as before by the surviving partner, Mr. W. E. Cattley.

The Universal System of Machine Moulding and Machinery Company, Limited, 97, Queen Victoria Street, London, E.C.4, have appointed Mr. M. L. Simpson, of 8, Queen's Gardens, Dowanhill, Glasgow, to be agent for Scotland for the sale of the company's machines in that area.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—In accordance with usual custom, business in the Cleveland iron market during the current week is entirely suspended for the Whitsun holidays, while there is little change to report from the quiet conditions prevailing previously. Meantime home consumption of pig continues on a very moderate scale, and although shipments from Tees ports for the month just closed show a marked improvement, the prospects for the immediate future are much less encouraging owing to the erratic movements of the exchanges abroad. The total shipments during May amounted to no fewer than 64,612 tons, 43,888 tons going abroad, 10,450 tons coastwise, and 10,274 tons were shipped from Skinningrove. The total for April was 48,238 tons, May thus showing an increase of 16,374 tons.

It can hardly be said that there is any improvement in the hematite trade, though there are hopes that business will look up a little after the holidays. The price of East Coast mixed numbers is down to 98s. per ton, and that is a full figure. But makers would probably shade 98s. for similar business. The No. 1 quality is at a premium of 6d. to 1s. per ton. In West Cumberland, Bessemer mixed numbers are quoted at £5 7s. 6d. per ton delivered at Glasgow, £5 12s. 6d. per ton at Sheffield, and £5 17s. 6d. per ton at Birmingham. Low-phosphorus iron is in fair request.

LANCASHIRE.—Conditions in the local foundry iron market continue quiet, buying now being reduced to almost retail quantities on a hand-to-mouth basis. There are still some sellers of Derbyshire iron who ask 95s. at the furnaces for No. 3 pig, or 102s. 6d. per ton, delivered in Manchester; but a far more general price now is 94s. (or 101s. 6d. here), and there are reports to the effect that 93s. has been accepted.

THE MIDLANDS.—All brands of foundry pig-iron are in very moderate request, and the competition is very keen indeed. Apart from Northants pig-iron, which has been sold at 88s. per ton, f.o.t., no further reduction from that previously reported is discernible. For an order of good tonnage the makers of the other brands would undoubtedly shade the present figures, which are indicated below. Consumers report that supplies can be obtained quite readily.

SCOTLAND.—Glasgow pig-iron market shows no new feature, and the tone prevailing is still dull. Consumers continue to buy only for immediate delivery, and the price remains unchanged at 99s. for No. 3 foundry at the furnaces.

Finished Iron.

The most remarkable thing about the recent Wages Board return is the way finished iron maintains its price and, indeed, increases. From the manufacturers' point of view, maintenance of prices seems to be the only possible policy under the prevailing conditions. According to most of them, there is very little profit in the business even now. High prices, however, are undoubtedly restricting demand and throwing a lot of business in the way of the re-rollers of foreign steel billets. Of course, iron cannot be altogether displaced, but for a lot of purposes it cannot compete with the very cheap steel stuff with which the market is flooded. A very restricted output of finished iron is bound to continue while these conditions prevail. Unfortunately there seems to be no prospect whatever of reducing the production costs of iron to such a level as will put it in successful competition with this steel. Demand is whittled down, until now iron is only being used for very special purposes for which steel is regarded as unsuitable. That being so, producers can command their price for the limited quantity required, but they are unable to command that volume of production requisite for complete success. It is a remarkable fact that, notwithstanding all the depression and stagnation, finished iron prices are maintained at so high a level. Last week's Birmingham market was very like its immediate predecessors in the comparative smallness of inquiry for iron. Quotations:—Marked bars, £15 (net f.o.t. makers' works); crown bars, £13; nut and bolt bars, £12; gas strip, £13 5s., all net delivered Birmingham area.

Steel.

Under holiday influences markets for steel are even quieter than usual, with business temporarily at a standstill. Transactions in soft basic billets are almost non-existent, and although the quotation remains at £7 17s. 6d., no business appears to be accepted at this figure, makers asking up to £8 10s., at which figure it is declared there is now very little profit. Medium basic billets are quiet at £10, but there is rather more doing in hard basic qualities at £10 5s. Acid billets are in only moderate request. The Stabilisation Committee met last week, and reduced the minimum selling price of coke tinplates by 10½d. per basis box. Business, however, has been very indifferent, buyers all keeping off the market as much as possible. Current quotations for the standard sizes may now be called:—Coke tins: IC 14 x 20, 112 sheets, 108 lb., 22s. 7½d. to 22s. 9d. per box; IC 28 x 20, 56 sheets, 108 lb., 23s. 1½d. to 23s. 3d. per box, with usual options, net cash, f.o.b. Bristol Channel ports. In the market for alloys the position of ferro-manganese is becoming increasingly difficult, but values as previously quoted are unchanged.

Scrap.

Business in all descriptions of scrap material remains quiet, and until work is resumed after the holidays buying is practically suspended. In Lancashire, however, there is a rather stronger feeling in the market for foundry scrap, and dealers here are trying to get the price up to 92s. 6d. for broken machinery metal, although some of them are still accepting 90s. delivered. With common pig-iron at 101s. this scrap is still cheap, but it is noticeable that the gap between cast scrap and pig-iron is not so wide as it was. Machinery cast-iron scrap for foundry use is still in poor demand in Scotland. There are few buyers, and 95s. to 97s. 6d. per ton is about the most that can be obtained. Ordinary cast-iron scrap in handy pieces is in practically the same position at 3s. 6d. to 5s. per ton less. The inquiry for old cast-iron railway chairs is better, and there are also a few shipment inquiries for this class of material. Merchants are reluctant, however, to part with any parcels at less than 97s. to 98s. 6d. per ton. Light cast-iron scrap is easier at 77s. 6d. per ton, and for the same class of material mixed with fire bars 2s. 6d. per ton less.

Metals.

Copper.—There has been little change for the better in the market for standard, but values on the week indicate a slightly firmer tendency. Stocks of copper in Metal Exchange warehouses at June 1 totalled 34,699 tons, an increase of 999 tons. Current quotations:—*Cash*: Thursday, £62 7s. 6d.; Friday, £61 17s. 6d.; Tuesday, £61 15s.; Wednesday, £61 5s. *Three Months*: Thursday, £63 7s. 6d.; Friday, £62 17s. 6d.; Tuesday, £62 12s. 6d.; Wednesday, £62 2s. 6d.

Tin.—During the past week the tendency in the standard tin market has taken a firmer turn, and values have appreciated to some extent, notwithstanding the adverse statistical position disclosed in the monthly returns. These, according to Ricard & Freiwald's report are as follow:—

STOCKS, LANDING AND AFLOAT, EUROPE AND AMERICA.—United Kingdom: Stocks in London, 693 tons; stocks in other ports, 2,303 tons; total, 2,996 tons. Landing and in transit, 763 tons; afloat from Straits, 1,390 tons; afloat from Australia, 150 tons; total United Kingdom, 5,299 tons. Holland: Banca spot, 1,105 tons; Banca and/or Billiton afloat to Europe and America, 1,257 tons. Continent: Straits afloat, 1,025 tons. United States: Spot and landing, 4,067 tons; afloat, 5,860 tons. Total visible supply, 18,613 tons. Current quotations: *Cash*: Thursday, £214 15s.; Friday, £216 15s.; Tuesday, £216 5s.; Wednesday, £216 10s. *Three Months*: Thursday, £214 12s. 6d.; Friday, £216 15s.; Tuesday, £216 5s.; Wednesday, £216 10s.

Spelter.—Dealings in this metal have been irregular of late, but firmer on the whole. Rudolf Wolff & Company state that Continental producers have manifested a little more desire to meet the market, though only very moderate sales are reported to have been effected. In the U.S.A. the position remains unchanged; the price has, on the whole, advanced, and inclines to follow the movements on the London market. Stocks of spelter in Metal Exchange warehouses totalled 628 tons on June 1, a decrease of 45 tons. Current quotations: *Ordinary*: Thursday, £31 17s. 6d.; Friday, £31 12s. 6d.; Tuesday, £31 15s.; Wednesday, £31 12s. 6d.

Lead.—The market for soft foreign pig continues steady with, if anything, an upward tendency in prices. This may be attributed largely to "bear" covering, for though consumption is good there would seem to be insufficient improvement in genuine trade demand to warrant an advance. At June 1 stocks of lead in the Metal Exchange warehouses totalled 7 tons, a decrease of 13 tons. Current quotations:—*Soft foreign (prompt)*: Thursday, £31 7s. 6d.; Friday, £33 2s. 6d.; Tuesday, £33; Wednesday, £32 2s. 6d.

XUM

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	61	5	0
Three months	62	2	6
Electrolytic	67	0	0
Tough ..	65	0	0
Best selected	65	10	0
Sheets ..	94	0	0
India ..	82	0	0
Wire bars ..	67	10	0
Do. June ..	67	10	0
Do. July ..	67	10	0
Ingot bars ..	67	10	0
H.C. wire rods	72	10	0
Off. av., cash, May	62	1	4 5/11
Do., 3 mths., May	62	18	10 5/11
Do. Settlemnt, May	62	0	8 2/11
Do., Electro, May	67	18	2 2/11
Do., B.S., May	66	11	11 1/3
Aver. spot price, copper, May	62	0	2 3/4
Do. Electro, May	68	3	5
Solid drawn tubes			13½d.
Brazed tubes ..			13½d.
Wire			10½d.
Yellow metal rods			7½d.
Do. 4x4 Squares			8½d.
Do. 4x3 Sheets ..			9½d.

BRASS.

Solid drawn tubes	12½d.
Brazed tubes ..	13½d.
Rods, drawn ..	11½d.
Rods, extruded or rolled	7½d.
Sheets to 10 w.g. ..	10½d.
Wire	10½d.
Rolled metal ..	9½d.

TIN.

	£	s.	d.
Standard cash	216	10	0
Three months	216	10	0
English ..	217	10	0
Bars	219	10	0
Straits ..	220	5	0
Australian ..	218	10	0
Eastern ..	216	10	0
Banca ..	220	5	0
Off. aver., cash May	218	13	0 5/11
Do., 3mths., May	218	0	10 5/11
Do. Sttlmnt. May	218	12	0 5/11
Aver., spot, May	218	7	6

SPELTER.

	£	s.	d.
Ordinary ..	31	12	6
Remelted ..	29	15	0
Hard ..	27	10	0
Electro 99.9	35	10	0
English ..	32	7	6
India ..	29	10	0
Zinc dust	41	0	0
Zinc ashes	13	10	0
Off. aver., May	30	14	7 25/46
Aver., spot, May	30	13	1½

LEAD.

	£	s.	d.
Soft foreign ppt	32	2	6
English ..	33	5	0
Off. average, May	28	15	0
Average, spot, May	29	8	6¼

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	37	10	0
Do. V.M. ex whf.	36	10	0
Dutch	36	5	0
Rods	44	0	0
Boiler plates ..	36	10	0
Battery plates ..	36	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	49	10	0
Chinese	41	0	0
Crude	27	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver ..	13	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
45/50% ..	..£12 2 6
75% ..	..£18 10 0
Ferro-vanadium—	
35/40% ..	..19/3 lb. va.
Ferro-molybdenum—	
70/75% c. free ..	8/3 lb.
Ferro-titanium—	
23/25% carbonless	1/3 lb.
Ferro-phosphorus, 20/25%,	£30 0 0
Ferro-tungsten—	
80/85%, c. free	1/4½ lb.
Tungsten metal powder—	
98/99%	1/8½ lb.
Ferro-chrome—	
4/6% car. ..	£23 10 0
6/8% car. ..	£23 10 0
8/10% car. ..	£23 0 0
Ferro-chrome—	
Max. 2% car. ..	£42 0 0
Max. 1% car.	£51 0 0
Max. 0.70% car.	£68 0 0
70%, carbonless	1/5½ lb.
Nickel—99%, cubes or pellets ..	£135
Cobalt metal—98/99%	10/6 lb.
Aluminium 98/99%	£125
Metallic Chromium—	
96/98%	4/3 lb.
Ferro-manganese (net)—	
76/80%, loose ..	£17 0
76/80%, packed	£18 0
76/80%, export	£17 0
Metallic manganese—	
94/96%, carbonless	2/- lb.
Per ton, unless otherwise stated.	

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten ..	s. d. 2 6
Finished bars, 18% tungsten ..	3 0
Per lb. net, d/d buyers' works.	
Extras—	
Rounds and squares 3in. and over ..	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do. under ¼ in. to ⅛ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in × ⅛ in.	3d. lb.
Do under ½ in. × ¼ in	1/- lb.
Bevels of approved sizes and sections ..	6d. lb.
Bars cut to length	10% extra
Scrap from high-speed tool steel—	
Scrap pieces ..	3d.
Turnings and swarf	1d.
Per lb. net, d/d steel makers' works.	

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	4	10	0	4	13	6
Bundled steel & shrngs.	4	5	0	4	10	0
Mixed iron & steel	4	5	0	4	7	6
Heavy cast iron	4	5	0	4	7	6
Good machinery for foundries	4	10	0	4	15	0
Cleveland—						
Heavy steel ..		4	5	0		
Steel turnings ..		3	7	6		
Cast-iron borings		3	5	0		
Heavy forge ..		5	15	0		
Bushelled scrap ..		4	17	6		
Cast-iron scrap ..		4	6	6		
Lancashire—						
Cast-iron scrap ..		4	10	0		
Heavy wrought ..		5	2	6		
Steel turnings ..		3	12	6		
London — Merchants' buying prices delivered yard.						
Copper (clean) ..		55	0	0		
Brass (clean) ..		39	0	0		
Lead (less usual draft)		26	10	0		
Tea lead		24	10	0		
Zinc		20	0	0		
New aluminium cuttings		95	0	0		
Braziery copper		46	0	0		
Gunmetal ..		44	0	0		
Hollow pewter ..		140	0	0		
Shaped black pewter		75	0	0		

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast—	
Foundry No. 1 ..	95/6
Foundry No. 3 ..	90/6
Forge No. 4 ..	88/6
Mottled	88/6
Hematite No. 1 ..	99/-
Hematite M/Nos ..	98/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	107/6
„ d/d Birm. ..	117/6
Midlands—	
Staffs. common* ..	102/-
„ No. 4 forge	88/9
„ No. 3 foundry	94/6
„ basic*	102/-
Shrops. Cold blast, ord.*	190/-
„ „ roll iron*	195/-
* d/d Birmingham.	
Northants forge	84/- to 85/-
„ fdry. No. 3	88/- to 90/-
Derbyshire forge	87/6 to 88/-
„ fdry. No. 3	93/6 to 95/-
„ basic	91/6
Scotland—	
Foundry No. 1 ..	104/-
„ No. 3 ..	99/-
Hem. M/Nos. ..	100/-
Sheffield (d/d district)—	
Derby forge	91/6 to 92/6
„ fdry. No. 3	97/6 to 99/-
Lincs. forge	99/-
„ fdry No. 3 ..	100/6
E.C. hematite ..	108/6
W.C. hematite ..	112/6
Lincs. (at furnaces)—	
Forge No. 4 ..	93/-
Foundry No. 3 ..	94/6
Basic	91/-
Lancashire (d/d eq. Man.)—	
Derby forge ..	94/-
„ fdry. No. 3 ..	102/3
Northants foundry No. 3	105/-
Dalzell, No. 3 ..	116/6
Summerlee, No. 3 ..	116/6
Glengarnock, No. 3	116/6
Gartsherrie, No. 3 ..	116/6
Monkland, No. 3 ..	116/6
Coltness, No. 3 ..	116/6
Shotts, No. 3 ..	116/6

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	12	10	0	to 13	0	0
Angles	12	15	0	to 13	5	0
Tees to 3 united ins.	13	0	0	to 14	0	0
Nut and bolt		11	17	6		
Hoops	14	10	0	to 15	0	0
Marked bars (Staffs.) t.o.t. ..		15	0	0		
Gas strip ..		13	5	0		
Bolts and nuts, ¾ in. × 4 in. ..		18	0	0		
Steel—						
Ship plates	£9/10	to	10	5	0	
Boiler plates ..		13	10	0		
Chequer plates ..		11	5	0		
Angles	9 12 6	to	10	0	0	
Tees	10 15 0	to	11	0	0	
Channels ..		8	17	6		
Joists	9 12 6	to	10	0	0	
Rounds & squares 3 in. to 5½ in. ..		10	10	0		
Rounds under 3 in. to ¾ in. ..		10	5	0		
Flats, over 5 in. wide and up ..		10	15	0		
Flats, 5in. to 1½in.		10	0	0		
Rails, hvy.	£9 0 0	to	£9	10	0	
Fishplates ..		13	0	0		
Hoops (Staffs.) ..		12	5	0		
Black sheets, 24 g.		13	0	0		
Galv. cor. sheets, 24 g. ..		17	15	0		
Galv. fencing wire, 8 g. plain ..		17	15	0		
Rivets, ¾ in. dia.		12	15	0		
Billets, soft	£7 17 6	to	£8	7	6	
Billets, hard	£10	to	£10	5	0	
Sheet bars	£8 3 9	to	£8	5	0	
Tin bars d/d (less rebate 7/6) ..		8	12	6		

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	2¾
Sheet	1	3¼
Wire	1	3¾
Rods	1	3½
Tubes	1	6½
Castings	1	1

Delivery 3 cwt. free.

10% phos. cop. £40 above B.S.

15% phos. cop. £50 above B.S.

Phosphor tin (5%) £30 above price of English ingots.

C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks ..	9d. to 1/5½
Ingots rolled to spoon size ..	1/- to 1/8½
Wire round—	
3/0 to 10 G. ..	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	22.40
No. 2 foundry, Valley	20.50
No. 2 foundry, Birm. ..	21.00
Basic	21.76
Bessemer	23.76
Malleable	22.26
Grey forge	21.76
Ferro-mang. 80% d/d	107.50
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess. billets	38.00
O.-h billets	38.00
O.-h. sheet bars ..	40.00
Wire rods	48.00
	Cents.
Iron bars, Phila. ..	2.47
Steel bars	2.20
Tank plates	2.20
Beams, etc.	2.20
Skelp, grooved steel ..	2.20
Skelp, sheared steel ..	2.20
Steel hoops	2.75
Sheets, black, No. 28 ..	3.60
Sheets, galv., No. 28 ..	4.80
Sheets, blue an'l'd, 9 & 10	2.80
Wire nails	2.90
Plain wire	2.65
Barbed wire, galv. ..	3.70
Tinplate, 100 lb. box ..	$5.50

COKE (at ovens).

Welsh foundry	40/- to 45/-
„ furnace	27/6 to 35/-
Durham & North. fdy. ..	45/-
„ furnace ..	24/-
Other Districts, fdy.	45/-
„ „ furnace	24/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	22/7½
„	28×20, „	45/3
„	20×10, „	33/6
„	28¾×14, „	23/9
C.W.	20×14, „	20/-
„	28×20, „	43/6
„	20×10, „	28/-
„	18¾×14, „	20/-

Terneplates 28×20, 1/3 per box basis below tinplates.

SWEDISH IRON.

Bars, hammered	£23/10 to £24/5
Rolled Ord.	£18/5 to £18/10
Nail Rods ..	£18/10 to £18/15
Keg. steel	nom. £30 0 0
Faggot steel	nom. £22 0 0
Blooms, Sngle weld.	£10 to £12
Do. Single & double	£13 to £14
Pig-iron ..	£7/15 to £8 0 0

All f.o.b. Gothenburg: